COLEAD

SECTOR STUDY

PROCESSED MANGO

Funded by the European Union

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This document is the mango sector study. This study explores the technical and economic feasibility of different processing and waste valorisation activities. The chapters can be found as standalones here: resources.colead

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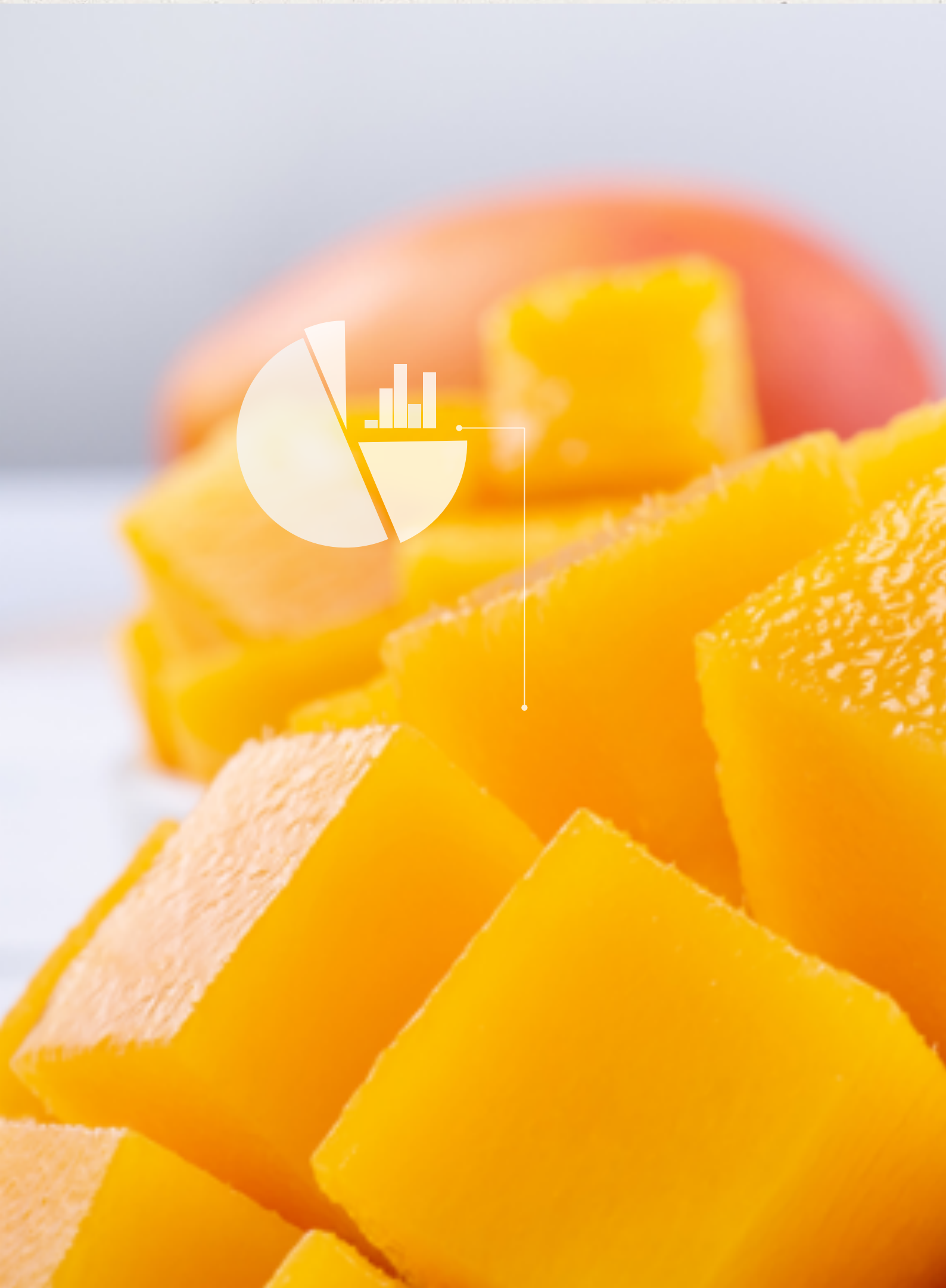

1 | FRESH CUT MANGO

This chapter has been developed by the Fit For Market + and Fit For Market SPS programmes, implemented by COLEAD within the framework of the Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union (EU).

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Contents

1. Fresh cut salads

1.1 What is fresh cut salad mango?

In developed markets, supermarkets sell freshly cut mango as a ready-to-eat product. Typically, local vendors who ripen mangoes in Europe supply mangoes for fresh cut salads. Fruit that is frozen can also be used. A small number of suppliers, such as Blue Skies in Ghana, have set up a way to send fresh cut fruit to Europe by air.

Retailers then typically package the fruit in to small single-person packs. The retailer's own brand is then imprinted on the cartons.

Spears

Mixed with other fruit

Cheeks

Spirals

Salsa

Figure 1. Fresh cut mango options

2. Demand

In much of Africa, mango is cheap and readily available when in season. The low cost of labour makes it easy to source fresh mangoes and cutting these at home or in hotels and restaurants.
In developed countries this is not the case. Mango is already an expensive fruit. It is also not very portable and cannot be eaten "on the go". As a result, fresh cut mango is a small, but premium segment. It also means that fresh cut mango is typically an export-oriented business, which services premium markets in Europe and the USA. For these shoppers, the sweet, sun-ripened fruit is superior to the fruit ripened locally in Europe and USA. This differentiator has in the past made the high price of this product somewhat more acceptable.

As a result, this niche has been a viable option for the few suppliers who have been able to develop the controlled logistics needed to deliver regular supplies to these key markets.

The consumption of mangoes in Europe is rising despite difficulties in sourcing and the preference for local seasonal fruit. The market prefers Kent and Keitt varieties and there is an increasing demand for ripened and freshly cut mangoes.

The market is unpredictable due to large fluctuations in supply volumes. There was also a shift in demand during COVID-19, but the market continues to grow (see Figure 2).

The short-term supply volumes and prices might be volatile, but with increasing global demand, mangoes with affordable prices will become accessible to European consumers. In Europe, the principal trade hub for mangoes is the Netherlands, followed by Germany, the UK, Spain, France and Portugal.

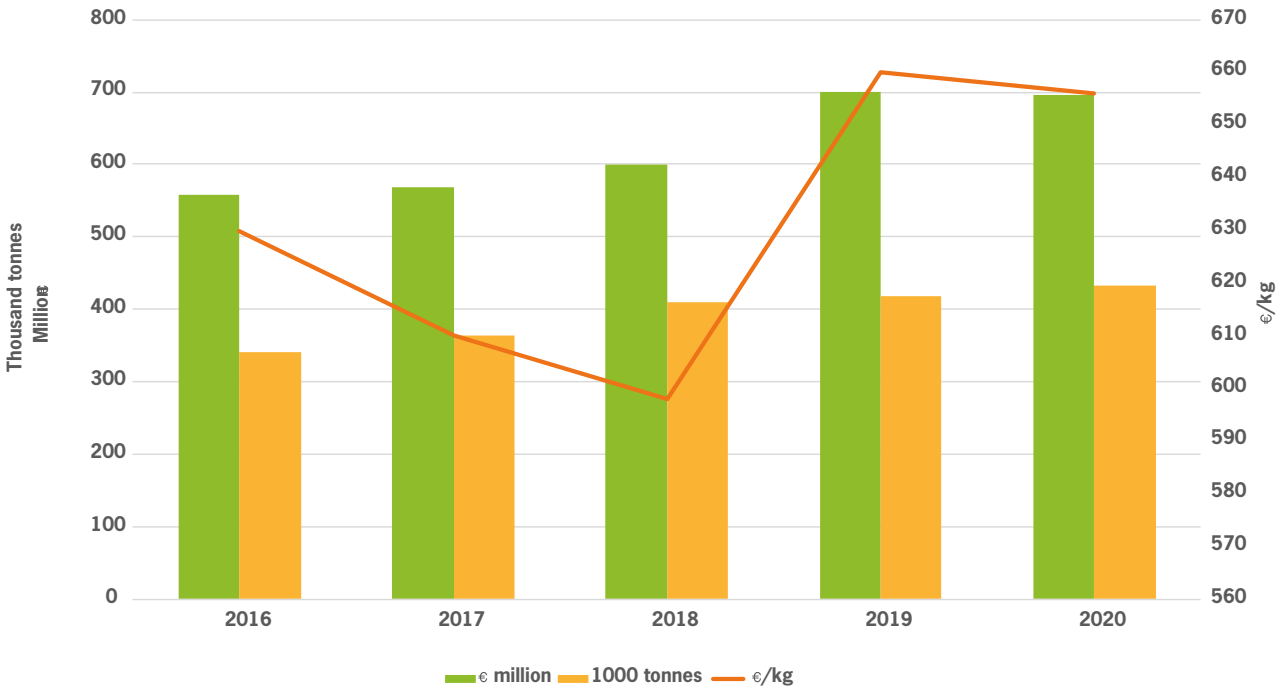


Figure 2. Imports of mangoes in the EU27+UK (including guavas and mangosteens). (Source: COLEAD based on Eurostat and UK Office for National Statistics)

2.1 Varieties

The main commercial varieties are:

- Kent (fibreless)
- Keitt (fibreless, productive)
- Palmer (minimal fibre)
- Osteen (typical variety in Spain)
- Tommy Atkins (long shelf life, fibrous but declining interest)
- Amelie (from Burkina Faso/West Africa)
- Shelly (from Israel)
- Kensington Pride (originated from Australia)

Minor commercial varieties are:

- Ataulfo (small Mexican variety)
- Nam Dok Mai (exotic variety from Thailand/South-East Asia)
- Alphonso (India, mainly ethnic market)
- Kesar (India, mainly ethnic market)

Each region has as specific preference for a variety. In the USA, Francine, Francis, Ataulfo, Haden, Keitt, Kent and Tommy Atkins are the most used varieties. These are mainly sourced from Mexico, Ecuador, Guatemala, Brazil and Peru. In the USA, 7-Eleven is a major importer of sliced mangoes.

Keitt, Kent, Amelie and Tommy Atkins are the most requested varieties in Europe. African producers also grow these varieties, making sourcing from Africa a viable option. Shorter airline routes and the cheaper logistics costs of air-freighted goods might make this a preferred option.

Developing countries are responsible for 88% of the total mango trade in Europe and supply 94% of European imports.

2.2. Market trends

This market segment is under severe pressure from several developments in the context of customers and retailers. These range from issues around rising prices and difficult logistics to sustainability issues. In the consumer world there are also some interesting trends around local sourcing that must be considered.

2.2.1 Convenience and "on the go"

However, eating a mango is not the most convenient thing to do, especially when you are on the move. Starbucks has created an on-the-go snack product that comprises pre-cut, ready-to-eat fruit, following the lead of merchants and restaurant chains such as Carrefour, Tesco, Albert Hein, Whole Foods, etc., as well as more health-conscious eateries and coffee shops such as Prêt a Manger.

2.2.2 Sun-ripened quality

Fruit that is typically sent to Europe is collected when it is still unripe, and then ripened locally in Europe. However, the sweetness and flavour intensity of sun-ripened fruit are indisputable advantages. Fresh cut salads that are air-freighted to Europe now have a market because of this.

2.2.3 Health and wellness

Mango is reputed to have numerous medicinal benefits, including boosting the immune system. Fresh fruit intake, including mango because of its high vitamin C content, has increased since COVID-19.

2.2.4 Rising prices of food

The complex logistics and the high price could, however, prove problematic in the current post-COVID, Ukraine–Russia conflict era. Will Europeans and Americans be able to afford this on-the-go snack? At the same time, concerns around the environment and the high carbon footprint of this product could also be a barrier.

Prior to COVID-19, fresh cut mango was in demand. However, disruptions to the supply chain became noticeable in retail stores, although this has now visibly reduced. There was a definite tendency to replace exotic air-freighted products with locally sourced fruits such as apples and berries. The demand for freshly cut fruit is anticipated to rise during the next few years in the USA. Since 2019, sales of freshly cut mangoes have climbed by 20% in the USA.

2.2.5 Rising cost of fuel and freight

Air-freighted fruit has always been a challenging model of production and distribution. In the past, suppliers relied on the lower cost of freight made possible by flights returning to Europe. Flight volumes are increasing, but they are not as numerous as in pre-COVID times. This has created some cost pressure on air freight and makes complex logistics even more complicated.

Rising global fuel prices are another significant issue, which might make air freight economically less feasible.

Sustainability and local sourcing

Shoppers in Europe and the USA have increased interest in sustainable production. For many of these responsible shoppers, air freight is an unnecessary luxury. The carbon footprint is just too high. As a result, everything from Peruvian asparagus to vegetables from Kenya is being questioned. Does it make sense to eat these vegetables all year? Or can European shoppers simply forgo these until they are in season locally?

For retailers, these products might be the simplest products to abandon when looking to improve their environmental credentials. It would improve their carbon footprints, while at the same time allowing them to focus on locally grown produce, which is increasingly in demand and on trend.

2.3. Case study: Fresh cut fruit, Woolworths

Figure 3. Fresh cut mango packaging from Woolworths

In a case study of fresh cut packed fruit at Woolworths South Africa, the three available pack sizes were purchased for study. All are packed using modified atmospheric packing with gas flushing for freshness and extended shelf life.

In the Woolworths fresh cut packed fruit range, the absorbent pad that lined the base of the pack to absorb excess moisture has now been removed to reduce waste and environmental impact.

The smallest pack, 180 g, has a black sticker, stating "Ideal for lunchboxes", prompting consumers to use this as a lunchbox or snacking option (Figure 3).

The next size up, 350 g, is perfect for home use, for a single or two-person family, but also enables a larger family to buy a selection of ready prepared fruit for the family's various taste preferences. Here locally sourced, "in season" and fresh is printed on the pack (Figure 4).

Figure 4. Small packaging of fresh cut mango

For the largest value or family pack, 750 g, we selected the tropical fruit salad, to show the ingenuity in the labelling. Again, they put seasonal, but the label clearly states "Mango/ Papaya/ Pineapple/Melon/Banana/ Kiwi/Grapes (seasonal)", giving the packer the opportunity to use what is in season without changing the labels.

Figure 5. Home use packaging

Figure 6. Bulk consumer packaging

2.4. Certifications, quality standards, etc.

Quality and food safety are crucial in supplying fresh cut salads to these markets – especially where this is air freighted.

It is crucial that processors deliver a quality product – for both taste and food safety. From the perspective of taste, retailers are looking for a perfectly ripe firm fruit that is flavoursome and has a bright yellow colour. For food safety, Hazard Analysis and Critical Control Point (HACCP) certification is a minimum standard.

Both conventional and organic fresh cut salads are sold in retail stores. But for most food services a conventional product is sufficient.

Growing interest in fair production means that social safeguards, labour safety regulations, etc., are all important for entry into this market. These should align to those desired by the retailers themselves. The leading supplier to Europe has several additional claims ranging from a programme to minimise waste to a foundation that invests in development of the local community.

Frozen product, which is more likely to be supplied to the food services sector, is slightly less challenging. While the specifications and quality standards are likely to be as stringent, but there is greater tolerance of lower social commitments, as the product is so rarely itself branded. This does not mean that these are not valued, but rather that they are a value-added offering that might provide more differentiation in a niche market.

2.5. Typical customers and end consumers

Fresh cut salads have two major outlets: retail stores and the food services sector.

Retail stores, especially premium urban stores, are the biggest market for fresh cut salads. They are the ultimate convenience fruit, offering a tidy, delicious, sun-ripened product within a day or two of picking. They are also a favourite at various motorway/highway convenience stores and other retailers supplying workers looking for healthy fresh lunch options.

The food services sector is another potential end market for fresh cut salads. Popular eateries that offer quick meals such as sandwiches and smoothies often also offer fresh cut salads that contain mango. Hotels and restaurants are more likely to offer fruit salad as dessert or at breakfast in fruit platters and salads. Bakeries are another potential end market for fresh cut salads. They use the fruit for fruit-filled pies and cakes. Finally, fruit salads are a popular item on the menu of airlines.

These outlets can use fresh cut salads (imported pre-cut or cut locally), but they are more likely to source frozen goods since they can be kept for longer periods of time and have less waste.

3. Supply

3.1. How do these products reach the market, what is the structure of the value chain?

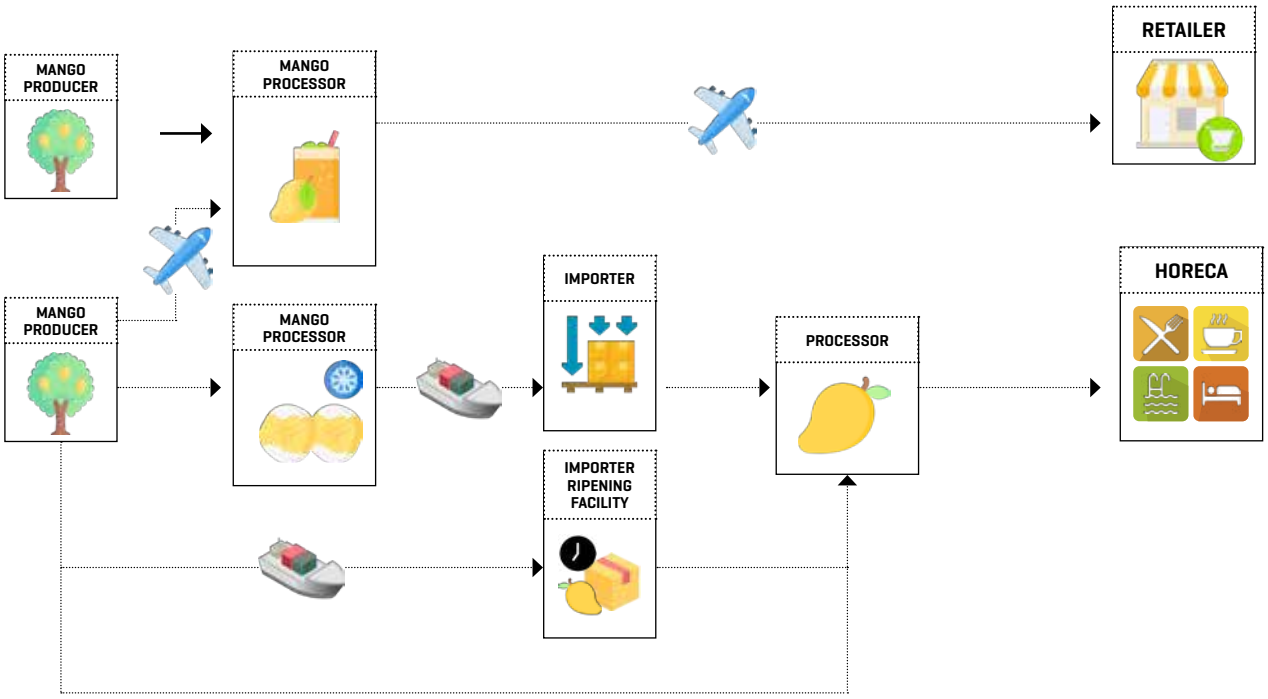


Figure 7. Value chain structure
HORECA: hotels, restaurants and cafes.

Fresh cut salad mangoes from Ghana to Europe or Mexico to the USA allow for processors to benefit from excellent transport links to the end market. Mangoes that are cut today can be in retail depots tomorrow.

In the case of Africa, fruit is sourced from a network of farmers and brought to the processing facility. This is located next to the airport, in fact kerbside, allowing for rapid dispatch and transport of packed product to Europe.

The processing model involves working closely with the retailers, especially as products need to be packaged in retailer packaging and in the desired pack sizes. Consequently, the processor is closely connected to the retailer and works alongside them to plan and satisfy orders.

3.2. Seasonality and availability

While fresh cut mangoes are always in demand in supermarkets, their supply varies by region depending on when they are harvested. Nevertheless, for retailers this can be solved by working with a supplier who is able to access fruit globally or regionally.

In Africa, sourcing to meet the fresh cut salad market happens regionally. Fruit is sourced first from Ghana, then from Côte d'Ivoire, Mali and Burkina Faso to fill in the rest of the annual calendar. This enables a consistent supply of fruit for fresh cut salads.

It is important for potential competitors, or those companies looking to ally with existing suppliers, to be aware of this sourcing calendar.

3.3. Technology, processes and techniques

The processing of fresh cut salads is a shorter process than that for dried fruit. In fact, some of the first few stages of production are shared (see Figure 8).

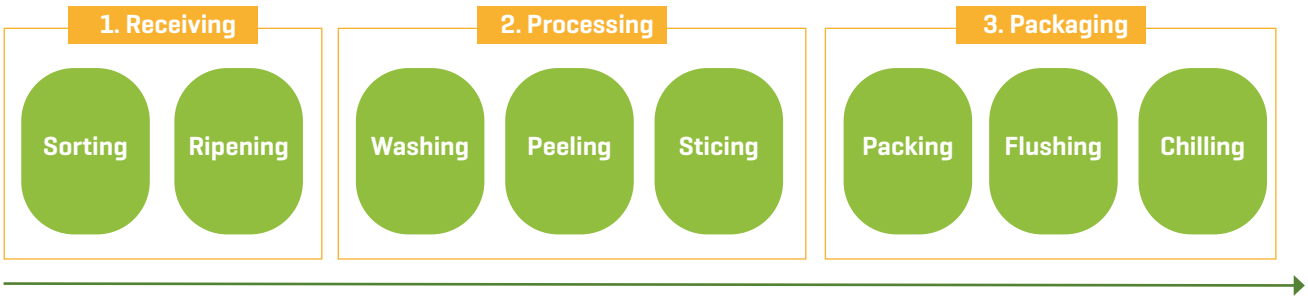


Figure 8. Processing and techniques

3. Supply

Stage 1: Receiving involves sorting the fresh mangoes so that you are certain of quality and that this mango is ready for cutting or ripening. Any unripened fruit enters the ripening programme, where it is allowed to ripen under controlled conditions.

Stage 2: In the processing stage, the ripe fruit is washed, peeled and then sliced. The fruit is conveyed to workers who are seated along a production belt. They then manually peel the product and slice or dice it depending on the specifications of the client.

Stage 3: In this stage the fruit is packaged in trays. The product is then flushed with nitrogen using a nitrogen-flushing machine. This removes carbon dioxide and oxygen from the packages. The packaged fresh cut fruit can then be sealed and blast chilled. This extends the shelf life and ensures the product can withstand transportation.

Stage 4: In this final stage the product is dispatched. It transported to the airport and is packed for onward distribution (see Figure 9, which includes temperatures).

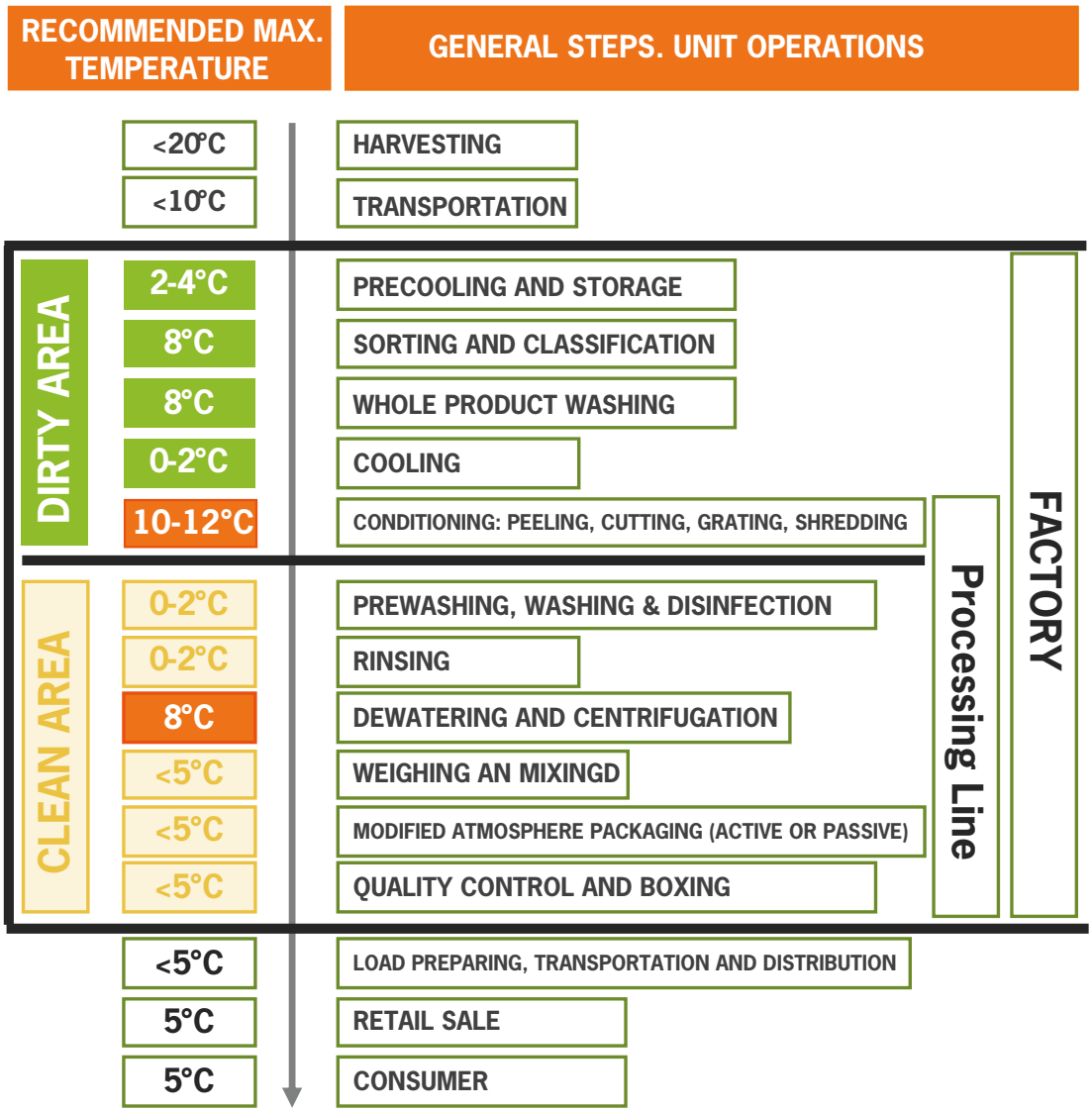


Figure 9. Flow chart of process with temperatures *(Source: www.intechopen.com/chapters/56159)*

3.4. Technology

Figure 10. MAP packing using nitrogen flushing
Source: Allbetter via www.Alibaba.com

The process of Modified Atmospheric Packing (MAP) or gas flushing has been practised since the 20th century to extend the shelf life of fruit and vegetables.

MAP technology consists of a collection of packaging line modifications that work to maintain a specific atmosphere inside the packaging. This controls and slows down the rate of oxidation of fresh food. Cut fresh fruit, when exposed to oxygen, turns brown and spoils, resulting in off-odours and loss of texture. By flushing the packages with harmless nitrogen gas (N_2) just before sealing, to displace the oxygen in the pack, the shelf life of the fruit and vegetables can be extended without the use of preservatives. This combined with chilled storage can result in cut fruit remaining in optimal condition for 5–7 days.

The packaging materials present a strong barrier to oxygen with low oxygen transfer rates to maintain the correct balance in the packaging. This technology allows consumers to maintain a healthy diet in a convenient manner, stocking up on fruit for a week, and having less waste.

The average cost for an in-line nitrogen gas flushing, continuous band sealing machine for punnets averages €3,500 from various manufacturers in China. The added cost would be the nitrogen gas used in flushing, which would vary according to pack sizes and quantities packed per day.

3.5. Ingredients for success

It is important to realise that success in running a fresh cut mango business involves management of a complex logistical puzzle. It requires speed of handling, good quality controls and access to a market that can afford the resulting high price of the fruit. As so much of the product is produced for retail brands, some degree of integration is needed with retailers. Developing capabilities to deliver product reliably all year is also essential.

3.5.1 Regional Sourcing Network

Processors that supply fresh cut salad mangoes must be experts at local sourcing and logistics because of the seasonality and requirement to fill the annual supply calendar. To make sure that export-quality mangoes are shipped safely, they will need to buy them from several countries and work with suppliers and logistics.

3.5.2 Operational excellence

Fresh cut mangoes have a short shelf life, so fruit quality must be good, handling must be swift but gentle, measures must be taken to protect and enhance shelf life, and integration with outbound logistics must be excellent. The best possible management of a cold product and swift air delivery to Europe is also needed. Companies that would succeed should ensure that they build the technical know-how for reliable sourcing. They need to secure a production location near an airport and ensure that they have good integration with airlines so that they can access outbound flights. Cancellations and delayed flights matter. Cold chain

management and mastering modified atmospheric packing is crucial. Finally, if packing at source, the factory should be skilled at smoothly changing over packaging so that they are not limited to packing for one client per day.

3.5.3 Variable profit management

Being able to sell year-round to retailers involves a regional sourcing strategy. However, this has an impact on profit margins throughout the year.

When the processor can source fruit locally the supply chain is shorter, logistics costs are lower and the mango is more affordable – especially in season. Out of season, they must source from further away. But they can benefit by sourcing from countries where mango is more available and sometimes cheaper. For example, mango is cheaper in Côte d'Ivoire than in Ghana.

Those companies that are better able to track and respond to these changes are better able to succeed. Those that fail to anticipate the changes to underlying profitability could miss opportunities for lower sourcing costs.

3.5.4 Reduction and valorisation of waste

Fresh cut fruit is a business with a great deal of waste. But, even with airports being industrial locations, there is some resistance to companies storing mountains of smelly waste nearby. This alone demands that companies find practical solutions to minimising and responsibly disposing of waste. Some companies already have extensive compost production programmes, while others use waste in biodigesters to produce biogas.

This is a high-risk model, with fluctuating profitability. But it allows those companies with good systems for transforming waste into value to benefit. First, they can make better use of second and third grade fruit: manufacturers of dried fruits or juices and the local fresh market could all be valuable outlets for rejected fruit. Second, they can sell waste from peelings to compost manufacturers.

This also allows these processors to develop marketing stories around sustainability that can make a difference in marketing efforts to retailers and shoppers in end markets.

3.5.5 World class account management and planning

Getting fresh cut fruit onto retailers' shelves within 48 hours makes integrated operations with retailers essential. This is only possible with a professional account management team and excellent supply chain management.

The teams managing retailer accounts should be close retailers – both geographically and in terms of professiona skills. They should ideally be skilled at relationship building and show a good understanding of the fresh food business, especially for products that need good cold chain management, quality control and rapid distribution.

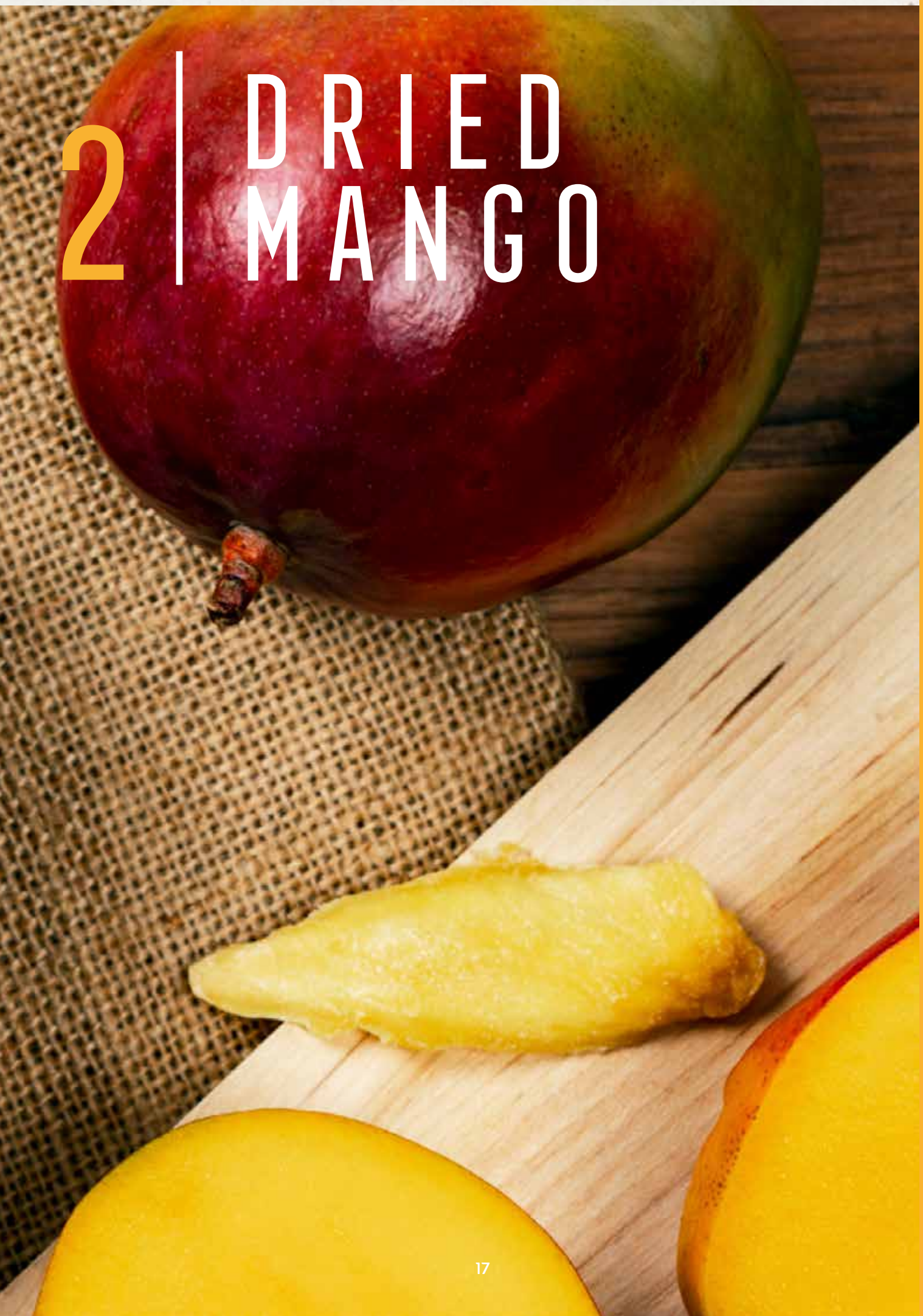
Outbound logistics need to be able to integrate into the supply chain systems of retailers. They should be able to integrate seamlessly into the supply chain and distribution centres allowing for improved planning of supply.

4. Issues and opportunities summary

Table 1. Issues and opportunities

Issues	Opportunities
▪ Technically and operationally difficult. It requires absolute precision. ▪ Entry-level technical obstacles. ▪ Account management is needed close to customers. This is a challenging skill and is costly too. ▪ CO2 emissions are high, which is not seen favourably by European consumers. In future, this type of product might be removed from product ranges for public relations reasons. ▪ Regional sourcing raises prices and complicates things. ▪ The model relies on stable, affordable transport. COVID restrictions on travel created a total freeze on air-freighted goods, which revealed the vulnerability of the business to changes in the airline industry.	▪ Few competitors. ▪ Regional sourcing to fill a yearly supply calendar. ▪ Maximising value by converting waste.

2 | DRIED MANGO



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Contents

1. Dried mango

1.1 What is dried mango?

Dried mango is the dried form of the mango fruit, typically eaten as a snack. Dried mango products come in eight different formats (Figure 1).

Air-dried mango

Freeze-dried mango

Candied mango

Freeze-dried powder

Trail mix

Dried mango roll

Fruit bars

Figure 1. Dried mango products

1 Dried mango

1.1.1 Air-dried mango

Mango pieces are air dried in a special dryer equipped with powerful fans and heat to create dried mango pieces, which are typically cut into strips. Air-dried mango is not the normal practice as the fresh mango is very wet and tends to brown if left to dry in the sun. The source of heat can be electric heating elements, gas burners, or heat exchangers fed with steam or hot water generated in a boiler fuelled by coal, biogas or biomass such as cashew shell or coconut shell. There has been consistent growth for more than a decade. The mango pieces are available as strips, chunks, cheeks and half cheeks.

1.1.2 Candied mango

The mango is dehydrated by placing it in a solution of sugar (reverse osmosis) and may have some additional air drying afterwards. This used to be the dominant format for dried fruit, but because of the large amount of added sugar is becoming less and less popular. Because the sugar also breaks down the fibre of the mango, candied mango is easier to eat. This allows more fibrous mango varieties to be used in production. However, much of the original mango flavour can be overpowered by the sugar, and the product appearance becomes a bit dull. This product can at times look and taste more like candy than dried fruit.

1.1.3 Freeze-dried mango

This product undergoes freezing at very low temperatures, dehydrating the mango pieces and creating a very crisp product with a distinctive flavour. It is still a small product category that has grown largely in the USA and is primarily supplied by China. To keep the product dry but undamaged, the production technique is intricate and challenging to maintain, involving careful management of logistics, air and moisture.

1.1.4 Freeze-dried mango powder

This is a ground form of freeze-dried mango. It is used as a dusting for confectionary and desserts, and is increasingly included mixed in powder supplements for smoothies, pre-workout drinks, etc.

1.1.5 Dried mango rolls and fruit rolls

In South Africa, dried mango rolls were created to recycle waste from overripe mangoes and flesh that was still attached to the pip. Although manufacturing the product is challenging, it offers growth potential. It is essentially a premium product made from waste. The mango flesh is ground to a pulp, which is poured in a thin layer in punnets that are than air dried in dryers. After drying, the mat of dried mango is rolled like crêpes and cut. The mango pulp can also be mixed with other fruit.

1.1.6 Dried mango/fruit bars

Mango and other fruits are combined with cereal in dried mango bars. These can be produced with mango pulp, which can also be mixed with other fruit pulps. They can also be made by grinding up second and third grade mango and extruding this into the shape of a bar.

1.1.7 Trail mix (fruit and nut mixes)

These are blends of dried mango and other dried fruits and nuts. Often small offcuts of dried mango strips are used.

1.1.8 Mango/fruit leather

These are typically mango pulp that is dried into a thin, flat, dry strip of mango. It is usually marketed as a children's snack.

1.2 Certifications, quality standards, etc.

There are clear quality standards for dried mango, especially air-dried mango, which is currently the most popular format. Table 1 provides an overview of the standard for most dried mango products.

Table 1. Overview of the standard for most dried mango products

Moisture and texture	14–17% moisture, hard but wet, easily consumed, not fibrous, not clinging to hands or teeth. This range allows for the product to be moist even after storing. Each customer sets their own moisture range depending on whether they wish to retail a dried mango as a soft, dry, moist product with nuts and seeds, etc.
Flavour	Clear mango flavour that is sweet with a hint of complexity and free of burnt flavour or preservatives.
Colour	Bright yellow or light orange, without any black or dark-coloured dots, or white spots.
Shape	5–8 cm long fingers or strips are preferred. Increasingly, importers also want chunks, which are strips cut into 3 cm pieces. Some importers also want thin cheeks and half cheeks, but consumers do not like them as they harden and dry out too quickly. Making these costs money because the smaller side pieces cannot be used.
Variety	Any variety that is low in fibre and has a distinct mango flavour can be used. Known varieties are Tommy Atkins, Kent, Keitt, Amélie, Brooks and Lippens. The best varieties have a combination of sweetness and acidity. But there is a market even for more acidic varieties such as Amélie, because many consumers like sweet and sour.
Stickiness	It is important the product is not too sticky and is "free flowing", which means the pieces are not stuck together or are at least easy to separate. Dried mango is packed by machine and, if it sticks together, it cannot be separated by machine and may get the packing line stuck. Separating by hand is too expensive in Europe and USA.
Certification	Hazard analysis and critical control point (HACCP) at a minimum, preferably British Retail Consortium (BRC). Importers can tolerate non-HACCP certified suppliers if they demonstrate to have implemented most HACCP principles and are about to be certified. There is a small market for fair trade, but mostly this is sourced from cooperatives directly by fair trade shops in small volumes.
Packaging: plastic bags	New 2.5 kg bulk bags of high-quality polythene preferably in transparent blue so that foreign objects are easily seen. Product needs to have space in the bag, so vacuum packing is to be avoided because it will create a large clump. Increasingly importers ask for nitrogen-flushed bags.
Packaging: cartons	New cardboard boxes of at least two-ply, capacity 10, 15 or 20 kg. 20 kg boxes need to be of excellent quality to prevent collapsing. If boxes collapse the mango is compressed and sticks together, and is rejected.
Transport	In 20- or 40-foot reefer containers at 5°C; product can be pallet or floor loaded to fit more. A 40-foot container will take 20–21 tonnes and is the more cost-efficient.
Preservatives	Increasingly, importers are looking for unpreserved, which means no sulphur. Citric and ascorbic acid are allowed for organic, but do not have a positive effect on the product or its shelf life. Conventional mango is either dipped in metabisulphite solution or sprayed before drying. Maximum residue levels apply.

The big conundrum in air-dried mango production is whether to use sulphur as a preservative

or not. Sulphur is very efficient in preventing the loss of colour and moisture, and preventing the product from becoming chewy. Vibrant colour is psychologically very important because it signals to consumers the product is made from good fruit. However, consumers increasingly want to avoid sulphur.

Some other ways in which the product quality and shelf life can be kept are:

- Respecting the cold chain, by storing the product in proper cold storage at 5°C and transporting in refrigerated containers; a room with air conditioners is not a cold storage
- Packing the product in proper bags and boxes, and limiting exposure to the sun
- Packing the product under nitrogen.

2. Demand

2.1 End market countries

The largest market for dried mango is in developed countries, with Europe sourcing the largest volumes from Africa. The USA tends to source dried mango from South America.

Within Europe, Germany is a major importer followed by the UK. Next, France and the Netherlands also import large volumes, followed by Switzerland and Italy. These countries all have large importing companies such as Besana in Italy, HPW & Gebana in Switzerland, and Farmers Snack and Seeberger in Germany who themselves distribute dried fruits in multiple countries.

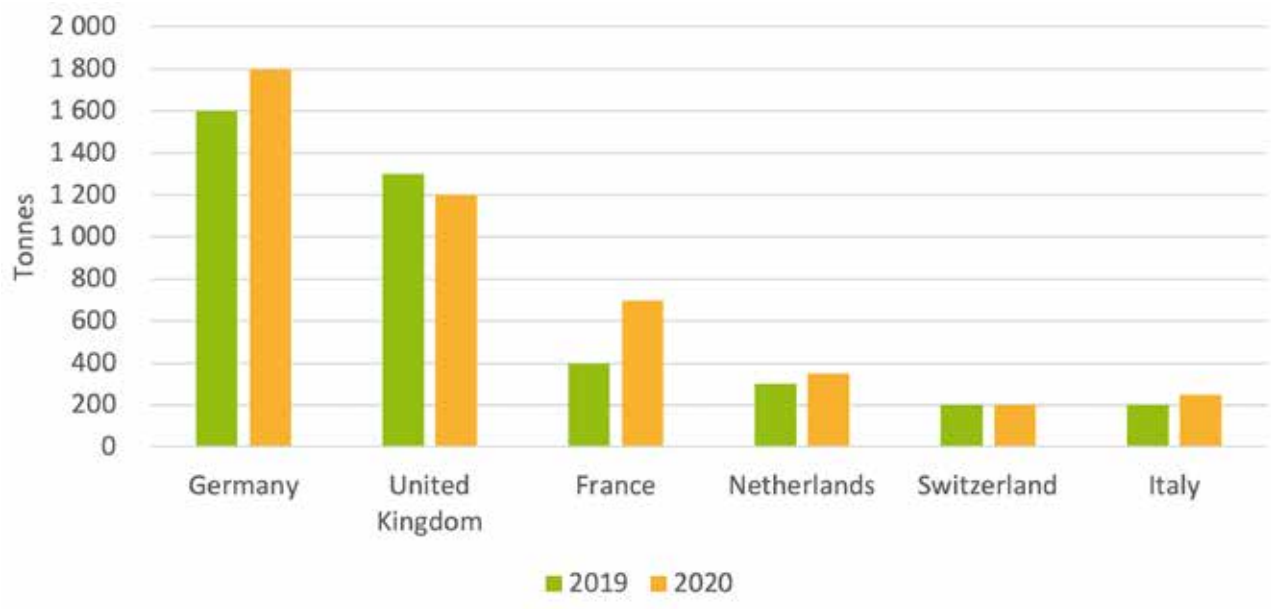


Figure 2. Main European consumers of dried mango, in import volumes (net re-export) (2019–2020)
Source: Autentika Global based on industry estimations.

2.2 Who are typical customers, distributors and end consumers?

Dried mango is an expensive snack. With the exception of South Africa and Nigeria, it is not common to find these snacks in the supermarkets and markets in most of the countries where it is produced. It is very much an export-oriented product. Usually, product found in these producer countries is second grade, rejected for export.

In contrast, in developed countries, dried mango has become a mainstream snack. It is sold in most retail stores and can be found in coffee shops, roadside stores and other stores that cater to lunchtime meals for office workers. This includes major chains such as Starbucks, Pret a Manger and Boots, and major retailers such as Tesco, Rewe, Albert Heijn, Carrefour.

There are differences between countries that are worth noting. Those countries where mango is well established have wider distribution, they have developed a variety of innovative product formats, have more brands trading and tend to have better quality.

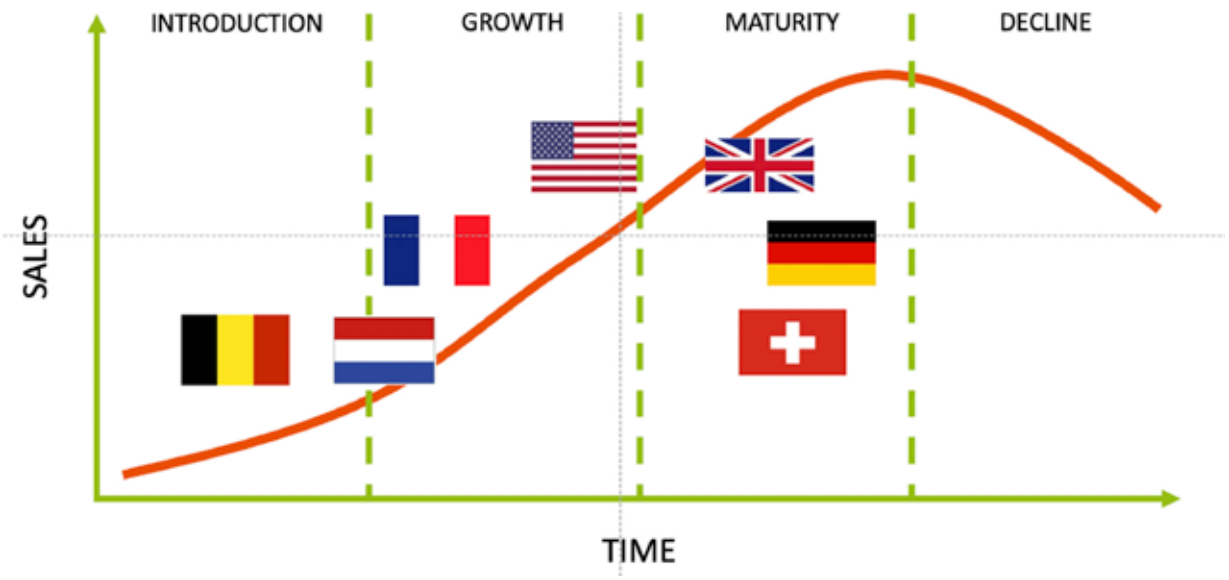


Figure 3. Market lifecycle

The most advanced countries importing dried mango are the UK, Germany and Switzerland. In the case of Switzerland, consumption per capita rather than overall volume is high, because of the small population size. Furthermore, Switzerland does not function as a redistribution hub for importers. These countries are mature markets, with many different products being offered from an assortment of established brands. These include bars, leathers, and snacks packs that contain nuts, etc. In the case of Germany, the mango flavour is so sought after that a recent innovation even coats cashew nuts with a mango flavour.

Next comes the USA, which shows wide distribution and is innovative when it comes to new dried mango slices and freeze-dried product concepts.

France and Ireland are showing growth in distribution. In France it is largely of German brands. But this remains limited to the dried mango slices themselves rather than further innovation.

Finally, trailing behind are the Netherlands and Belgium, where distribution in most retailers is poor and product quality is questionable. Most quality product can be found in open markets.

The Scandinavian markets have shown great interest in dried mango, but more will need to be done to explore this opportunity. Southern Europe does consume dried mango, but the purchasing power there is not the same; moreover, culturally they are more focused on local fruits. The same is true for Eastern Europe, which lags in terms of the penetration of fresh tropical fruit and other exotic foods.

2.3 How does the product reach the end market, what is the structure of the value chain?

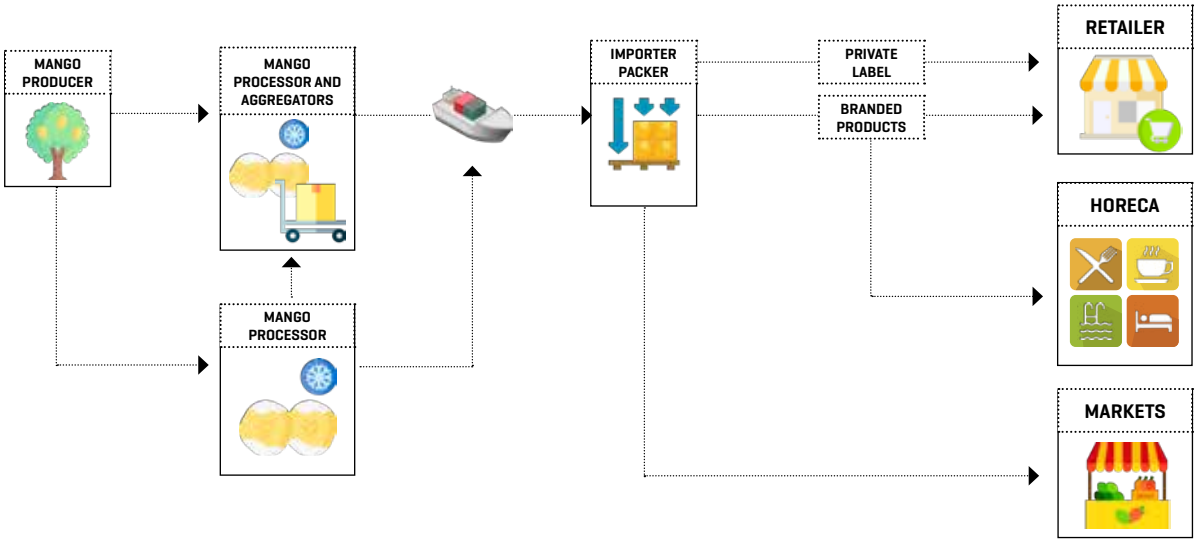


Figure 4. Dried mango value chain

The value chain is rather straightforward, and the exporters and importers play a crucial role.

Larger mango drying factories, which purchase mango from nearby plantations, manufacture the majority of dried mango. These tend to be fully certified modern factories. A few of the larger exporters, especially in West Africa, purchase dried mango from numerous smaller manufacturers that are unable to export directly. They serve the role as a sort of exporter–intermediary in the process and help to consolidate volumes and carry out quality control in the supply chain. They also mobilise working capital. Some of these have both their own plant and buy in from third parties. In Figure 4 they are called "processor and aggregator".

The product is supplied to importers who tend to specialise in dried fruit and nuts, or in a wider range of organic food products. Some importers market the product under their own brand, while others allow retailers to sell the product under their brands. Combinations are also possible, where importers market their brand in premium supermarkets, while also supplying discounters with private labels. Several large importers with own brands can pack the product in their own facilities, while others make use of contract packers.

There are also many importers who sell to other brands and co-packers. For example, a Dutch importer may sell to a German importer who then packs for a local retailer. Particularly in the organic segment where volumes are often more limited, there are intermediaries. And again, combinations are also common where one part is marketed to a retailer, while the other part is re-exported to another importer.

Though the Netherlands is not an important consumer of dried mango, there are several large importers based there that re-export product across Europe, such as Berrico and Tradin, as well as smaller ones that also resell, such as Horizon and Afrifruta.

Germany has several large brands. Seeberger, Kluth and Farmer's Snack import directly, but also buy from other traders in Germany and the Netherlands. Rapunzel and Biovisio

are smaller and focused on reselling. Besana is a large importer from Italy, while in the UK Mango Trading, Greencell and Preda are known players.

In some countries, open markets remain an important channel for distribution of nuts and dried fruits. Smaller importers typically service these market sellers and provide a helpful outlet for product that might not be able to be packed on mechanised packing lines. They tend to deal in pallets rather than containers.

Many fair-trade shops source dried mango directly from smaller producers in developing countries, usually cooperatives. However, their volumes are small and often not enough to fill a container, which makes transport expensive. Furthermore, each country tends to demand different certificates for organic and fair trade, which increases certification cost enormously.

There is also a fair amount of vertical integration in the sector. Gebana, HPW, Greencell, Tradin, Afrifruta and Biovisio are all European importers that have also invested in production in Africa. They either own shares in plants or have made long-term partnerships whereby they, for example, pre-finance equipment and working capital.

There is also an important difference between North America and Europe. In Europe, importers pick product from the port and take care of all formalities from there. However, in the USA the customers, even importers, expect the exporter to do all this and deliver to their doorstep. They are also a lot less forgiving when product is late, or something changes, and can easily impose penalties. This makes export to the USA a lot more difficult. Moreover, competition from Mexican dried mango is stiff, which also makes prices lower in that market.

2.4 Market trends

Dried mango consumption has benefited from a few a few powerful market trends related to health and wellness, interest in diverse flavours including new fruits and foods, and the growth of snack markets. On the other hand, increased demands for sustainability and food safety have put pressure on suppliers and pushed the sector to more professional production. Some important trends affecting demand and the supply chain are described below.

2.4.1 Exotic foods

Exotic, tropical and one-of-a-kind fruit tastes are becoming popular as customers seek fresh and unusual experiences in the foods and drinks they consume. The desire to explore may have been motivated by a desire to escape from repeating cycles and find a source of enjoyment during the COVID-19 pandemic. Furthermore, many customers believe exotic and tropical fruit flavours provide perceived health benefits such as immune system health, relaxation and other benefits.

Figure 5. Exotic fruits

This trend continues to underpin the success of dried mango in western markets. But it also has led to new flavour innovations where dried mango is infused with chilli or lime.

2.4.2 Nutritionally dense foods

Figure 6. Nutritionally dense food

During the pandemic we saw many turning to traditional medicines as well as healthy foods to strengthen their immune systems. This remains an important consideration for many people, fuelling interest in herbal teas, superfoods, and fruit and vegetable powder supplements. These functional foods promise to be tasty, while supercharging smoothies and drinks with natural vitamins and minerals.

The return to a less sedentary lifestyle after COVID and a return to the office has sparked interest in weight loss. For many people it is not enough to simply cut calories, they want to enjoy natural, nutritionally dense, low-carbohydrate foods such as seaweed crisps, dehydrated fruits, mushroom biltong, date balls, snacks containing ancient grains and seeds, multigrain and seed snacks such as date – this is creating new opportunities for fruits as well as for nuts and cereals.

For dried mango these trends offer opportunities, especially in healthy snacks and in the supplements segment, where superfood powders can include dried mango powder.

2.4.3 Sustainable, ethical consumption

All over the world, people have embraced many new sustainable eating habits, such as wasting less food, which is one of the most effective acts for addressing the climate catastrophe. For many this is about turning to whole foods such as minimally processed fruits and vegetables. For others this trend is about ensuring that the foods they eat have a smaller impact on the environment.

Being able to demonstrate more sustainable production, reduction of waste and better working conditions for employees are all positive stories that can help to improve the marketability of products.

Figure 7. Ethical consumption

Figure 8. Clean eating

2.4.4 Clean label

Younger consumers are adopting a "clean eating" diet that emphasises entire foods (e.g. fruits and vegetables, lean meats, and healthy fats) and less processed or packaged goods. The clean label trend has evolved to focus not only on added preservatives, but now also includes many "free from" products such as plant-based meats, gluten-free products,

lactose-free dairy.
According to Market Data Forecasts, global sales of clean label components such as natural colours and flavours, starch and sweeteners, fruit and vegetable ingredients, flours, and others will increase from US$38.8 billion in 2021 to US$64.1 billion in 2026 at a compound annual growth rate of 6.8%.[1]

Traceability and being able to maintain a free-from status of dried mango might be more important in future.

2.4.5 Air fried and process-lite

The last few years have seen air fryers become mainstream kitchen appliances. Behind this trend is a general interest in low-fat, healthier, low-processed food preparation. For many that means buying meal kits where you can assemble your own foods. But also sourcing foods that are as natural and unchanged as possible. Date balls, raw cacao and muesli (overnight oats) are all a part of this trend.

This bodes well for dried mango producers who use natural air dryers and can promise an unaltered product. This seems to be an important part of marketing in developed markets.

Figure 8. Clean eating

1 www.ift.org/news-and-publications/food-technology-magazine/issues/2021/september/columns/ingredients-clean-label

3. Supply

3.1 Suppliers to the market

Naturally dried mango is produced by countries that can grow mangoes. However, there are some regional differences and there have been some shifts in production of dried mango and in suppliers to the global market.

First, the Philippines, which has historically been the market leader, tends to produce candied mango, which is made by submerging mango pieces in sugar baths. Allegedly many of their varieties are fibrous, which could explain why they have failed to move to air-dried mango. As the trend for healthy natural foods gained traction in the 2010s, candied mango has been in decline. Only in the UK it is still easy to find, partly because some of the importers tend to obscure the fact that a lot of sugar is added, for example by still calling the product "natural". The Philippines is becoming a far smaller actor in the chain. There are some signs that they are introducing innovative new flavours in the hope of revitalising this segment.

As air-dried mango has grown, so has Africa's share of this snack category. South Africa, which has a long tradition of eating dried fruit products domestically, was for many years the market leader in producing conventionally grown air-dried mango. Shortages of fresh mangoes in that country have slowed production and South Africa has lost considerable market share as the market has grown. Another challenge South Africa faces is the production of unpreserved (unsulphured) mango, which seems more difficult to do with varieties such as Kent. Finally, there is no organic mango in South Africa, which closes the door to that segment. Nevertheless, South Africa remains a quality benchmark in the industry.

To overcome these challenges, a few large South African processors have invested in West Africa, enabling production using cheaper, more readily available mango production during the South African off-season. The knowledge they have brought has revolutionised the sector there.

West Africa has seen tremendous growth in production over the past decade, largely due to South African investors, but also to donor support to the sector, combined with hard work from local entrepreneurs. For example, exports from Burkina Faso rose from 150 tonnes in 2009 to 3,500 tonnes more recently. Burkina Faso is now the largest supplier to Europe and produces both conventional and organic products. Its main trump cards are some of the best tasting mangoes for drying and the fact that most product is organic certified.

However, with more than 100 factories the sector is very fragmented. Quality and customer service remain issues. This is illustrated by the low number of factories with HACCP or BRC certification and with English-speaking staff. Very few factories even have dedicated sales staff. What is also worrying is that there is subcontracting in the industry at factories that are far from even having the basics of food safety in place. Often this kind of subcontracting is hidden behind exporters, which themselves in some cases are certified.

Ghana has been a consistent supplier for the past ten years. There are at least two sizable facilities producing roughly 1,400 tonnes of product per year combined. A smaller number of processors now also produce for local sales, for airlines and for export. Sometimes they connect with larger exporters in Burkina Faso, or even in Nigeria which has a developing local market for dried mango.

Mango prices in Ghana are, however, relatively high, and therefore production is only marginally profitable in large well-managed factories that also process other fruits such as pineapple and coconut. So, to expand or scale up production they are forced to source mango from Côte d'Ivoire. HPW, the largest factory, has built a plant in Côte d'Ivoire and sources mango from independent factories there and in Burkina Faso.

Côte d'Ivoire remains home to large untapped potential. With high availability of the prized Kent variety at low prices, and ample experience in the logistics of fresh fruit export, it should be a dried mango powerhouse. But progress has been slow, and it remains a small player for now.

Mali continues to have a relatively small presence in the market. There is still work to be done to improve factory management. Senegal has tried, but because of the high domestic fruit prices has limited potential to develop for now. Mozambique has one foreign-owned plant that has been going strong, while Malawi is also exploring opportunities. Finally, Kenya seems to be working hard at building an industry.

South American producers are, not surprisingly, oriented on producing for the USA. Mexico, which also supplies fresh mango to the USA, is well placed to supply this market with dried mango, and consequently supplies most of the market there. In addition, it has also started to export to Europe. Finally, Ecuador is an emerging small-scale producer that supplies to the USA and Europe. In the past South Africans also invested in Peru, but this did not lead to a large export industry. For now, Peru seems to focus processing on individually quick-frozen (IQF).

3.2 Seasonality, variety and availability

For dried fruit production the variety of mango is important. A fibreless variety, with larger fruits (for processing efficiency) is the ideal. It should have bright, dark-yellow or light-orange colour when dried and have natural sweetness as well as acidity. The best varieties are Kent and Keitt (grown in South Africa, Ghana and Côte d'Ivoire), which are fibreless and produce excellent colour and flavour, and can be very efficiently processed. Because of their size, they can reach a processing efficiency of 13 kg of fresh mango for 1 kg of dried mango, or even 10:1 if ripe fruit and leftovers are used for rolls and bars.

The best flavour comes from Brooks, a late variety grown in Burkina Faso and Mali. But this variety is smaller and more susceptible to fruit fly. Amélie has a good flavour but is more fibrous and acidic. Interestingly, the acidity seems to be preferred by about 30% of consumers. Unfortunately, a lot of importers do not like it and believe that customers will not either. So, it has been challenging for processors to market this variety, especially if it is not organic.

Another variety that was tried is Palmer, which is grown in Ghana. But this experiment was unsuccessful.

Lippens in Burkina Faso is now also widely used for export markets, despite lacking the acidity to create a strong and complex mango flavour. It is gradually being accepted because of a shortage of good product on the market.

The timing of the mango season differs from country to country across Africa. First, the countries in the Southern Hemisphere tend to bring fruit to market in December–April, with Mozambique being one month ahead of South Africa due to its warmer climate. Most of West

Africa has mango from late March or early April to late July. The north of Senegal, however, has a later season that goes until the end of September. Ghana also has a small minor season later in the year, but production is too small and thus prices too high to use this mango for drying. Kenya has multiple seasons depending on the region (see Table 2).

The complementarity between seasons makes it attractive for South African producers to also invest elsewhere on the continent. First, they can offer mango throughout the year to their clients. Second, they can diversify the risk, because they can now compensate a bad season in one region with a good season in the other. Importers on the other hand are also looking to source mango year-round as opposed to having to buy large quantities in one place and store it.

Table 2. Seasonal calendar for regional sourcing

	J	F	M	A	M	J	J	A	S	O	N	D
Senegal												
Burkina Faso												
Mali												
Côte d'Ivoire												
Ghana												
South Africa												
Kenya												

	Major season
	Minor season

In West Africa, this seasonal calendar allows for regional sourcing.

3.3 Drying process

3.3.1 Overview of the process

Producing the right quality of dried mango is almost an art. It requires professional equipment, a well-trained workforce, a well-organised factory and production process, and a lot of experience. A typical mango drying factory has 80 to 500 workers, depending on the production scale, level of automation and organisation, and labour productivity.

All of this means that it is impossible to start a large factory from scratch. Even if you would have the funds to build a new plant with six dryers that can process 1,500 kg of fresh mango per day, you would only be able to operate one or two dryers during the first year. The only exception would be if you bring in experienced managers and section managers from elsewhere, and you have long experience in local sourcing.

We describe the various stages of the production process below. The production can be

split into four major parts, that have further steps:

1. Reception, sorting, washing and ripening
2. Peeling and cutting, and loading on trays (the wet or "dirty" side of the factory)
3. Drying
4. Sorting, finishing and packing.

Professional factories manage the performance of each of these sections individually. Workers have targets in terms of efficiency and quantity to be processed daily. Only in this way can the factory control the biggest determinant of profitability in drying, which is the ratio of fresh fruit to dry fruit.

3.3.2 Production benchmarks

The most important production benchmarks to ensure good conversion of fresh to dried fruit in dried mango production are as follows.

- Processing efficiency, which is the number of kilograms of fresh mango needed to produce one kilogram of dried mango. With varieties such as Tommy Atkins, Kent, Amélie and Keitt, 13:1 is a normal ratio. For smaller mangoes such as Lippens and Brooks, 15:1 is more realistic, though late-season varieties such as Brooks often end up at 18:1 due to high rates of fruit fly infections. As a late-season variety, Keitt also suffers from fruit fly, but this is compensated for by the large size of the fruit, even larger than Kent. Large fruits have a more favourable flesh to pip-and-skin ratio.
- First grade percentage, which is the part of the production that can be sold as first grade. Efficient factories can reach 92% first grade, 6% second grade and 2% rejects.
- The number of kilograms needed for 1 kg of first grade, which is a combination of the previous two. Since many factories struggle to sell second grade product at good prices, this is a very important benchmark.
- Average production per day and total production per season. This tells you how efficiently the factory is used, and how close it operates to maximum capacity. This is often determined by how good it is in selling product and sourcing raw material.
- Amounts of gas (kg) and of electricity (kWh) per kilogram of dried mango.
- Work-hours per kilogram of dried mango. Since production is very labour intensive this is a major cost driver.

Ideally, the factory has benchmarks per section that are monitored daily, so that the production manager knows why the efficiency is low and can put corrective actions in place immediately. The most important ones are the ripening loss, and the percentage of slices from fresh mango, which should be around 50–55%.

3.3.3 Part 1: Reception and ripening

Harvesting: Though often not controlled by the factory, proper harvesting and transport will prevent large losses in the production process. Good factories train suppliers on these aspects. Mangoes should be harvested that have the right ripeness. They should not be on the ground, should be correctly cut from the trees and stored in crates in the shade, with space between crates for air circulation. Transport should be done in crates, and open trucks should be covered. Mangoes that are bruised or have fallen on the ground will give problems during ripening.

Fruit reception, washing and sorting: All of the fruit needs to be inspected to ensure it meets

the quality standards. The fruit should be of the right variety and at least 12 Brix on acceptance at the factory (i.e. it is not overripe). This will need to ripened to 16–18 Brix. Overly soft fruit is difficult to peel and cut, and tends to become too dark in colour. The mango should be disease free (i.e. free from fruit fly and other pests). The fruit should be completely intact, without bruises, cuts or open skin. If you have a fruit ripening programme, which is advised, then unripened fruit can be accepted. If not, then the company should receive fruit that is ready for processing within a day or two of arrival.

The fruit should be washed and sorted straight away – for ripeness and whether accepted or rejected. Mango that is too ripe or infected or too small, or harvested immaturely should be rejected. Rejects are normally not paid and returned to farmers or dumped. At the end of the sorting process, there should be three to four groups, with one being rejects and the others stages of ripeness.

Many factories in West Africa tend to ripen first and then wash. However, this leads to large losses during ripening. Some mangoes ripen slowly. Others will ripen faster, leading to more losses during ripening and more sorting needed. Dirt also hides signs of infections that will infect other mangoes during ripening. Finally, the washing forces sorting to take place. When factories are in the middle of the season, they often do not take the time to sort, which leads to huge losses in ripening.

After washing and sorting, the fruit should be ripened. Mango should be packed in plastic crates with ventilation openings – either 30 kg picking crates or 450 kg bulk bins. There needs to be space in between stacks of crates for air circulation. Ideally, the company uses closed ripening rooms with fans for homogeneous ripening. More advanced ripening rooms have temperature control to slow down or speed up ripening, and moisture and carbon dioxide (CO_2) control. Ethylene can be used to speed up ripening, but this is often not necessary. Ripening takes 4 days in open air, down to 2 days in the most advanced ripening rooms.

Mango ripening in open air is also possible, but it should be in crates under a roof, and the ripening area should preferably be closed off with nets to keep out flies.

During ripening, further sorting may be necessary, where the ripest mangoes are sent to production to avoid spoilage.

The main goal of the ripening process is to ensure the factory has the same number of ripe mangoes available for production every day, with minimum losses.

Common practices that should be avoided are:

- Transport of mangoes in bulk
- Offloading mangoes on the floor in big piles
- Ripening in large concrete basins or closed wooden crates
- Washing after ripening
- Covering mango with plastic to speed up ripening.

3.3.4 Stage 2: Peeling and cutting

In stage two, the mangoes are peeled, cut, and loaded on drying racks or trays. Before mango is released for production, ripeness should be checked with colour charts and refractometers. Conventional mango is treated with metabisulphite before drying. This preservative prevents discoloration and spoilage in dried fruits due to its antioxidant effects.

The target of this phase is to fill the dryers as quickly as possible. Most new factories fail to utilise their production capacity because they cannot cut enough mango to fill the dryers. In addition, if the teams take too long to fill a dryer, the mango starts to brown and will be rejected at the end. This requires very strong operational control, especially when mango suppliers are trickier to find in the early or late season.

Peeling still takes place by hand because this is still the most efficient method. Each mango has a different shape, which makes it difficult for machines to peel them without either leaving skin on or cutting away too much flesh. Furthermore, automatic peelers tend to be very expensive and have limited capacity. Each mango needs to be peeled separately by the machine. This means that where labour cost is low, it is much cheaper to peel by hand. It is very important to use special peelers instead of normal knives because the latter take too much flesh.

After peeling, the two large cheeks are cut off, and either sliced by hand or by machine. Several factories have experimented with hand slicers, but these are not more efficient than hand cutting. More advanced factories place the cheeks lengthwise on a transport belt, that has knives at the end that slice the mango.

Pre-treatment with metabisulphite can be done by dipping the cut slices in a stainless-steel bath containing a solution, for which even plastic shopping baskets can be used. Modern factories spray the solution on the mango with a machine. If the dipping method is used, the pre-treatment needs to take place in a well-ventilated area.

The best factories weigh the content of each drying tray to ensure it is not overloaded, which would increase drying time.

It is crucial to weigh the mango that is released to the factory and the pieces loaded in the dryer. This will tell you if there is an efficiency problem.

3.3.5 Drying

Depending on the type of dryer, the type of mango, the amount of mango loaded and the outside temperature and humidity, drying takes between 16 and 24 hours. Mango that has more sugar and fibre is more difficult to dry, while if the outside air is humid drying also takes longer. Overloading the dryer will also increase drying time. Hence, there is an optimum that each factory needs to find.

Depending on the type of dryer, the drying racks need to be changed once or many times to ensure homogeneous drying. In any case, progress does need to be monitored even if the dryer has full humidity and temperature control and standard drying programmes, because each batch can be different.

After drying, the product needs to cool on the racks in a separate area before it can be removed from the racks, for which plastic scrapers are used. The mango should then be placed in closed bins for 24 hours to homogenise. The wetter pieces will transfer moisture to the dryer pieces in this process. After homogenisation the mango can be stored until there is capacity to do grading and finishing.

3.3.6 Finishing and packing

The final step is the sorting and finishing. The dried mango is sorted on the basis of colour,

size and texture. Anything that does not meet customer specifications is second grade, while anything inedible is rejected. Pieces that are too large need to be cut to size, and black edges need to be cut off.
After sorting and grading, the product should be packed to avoid loss of quality. This is normally done in certified food-grade good-quality polythene bags, preferably blue ones. The content is 2–2.5 kg per bag, and the product should be free flowing. Bags then get packed in new 10–20 kg two-ply cardboard boxes.

Ideally, the dried mango is packed under nitrogen; the air in the bags is removed and replaced with nitrogen. The absence of oxygen will stop the ageing of the mango.

Though fully automatic machines are seldom used because they seem expensive, they can end up saving money because they can weigh the bags accurately and avoid losses coming from staff putting too much in a bag.

Moisture control

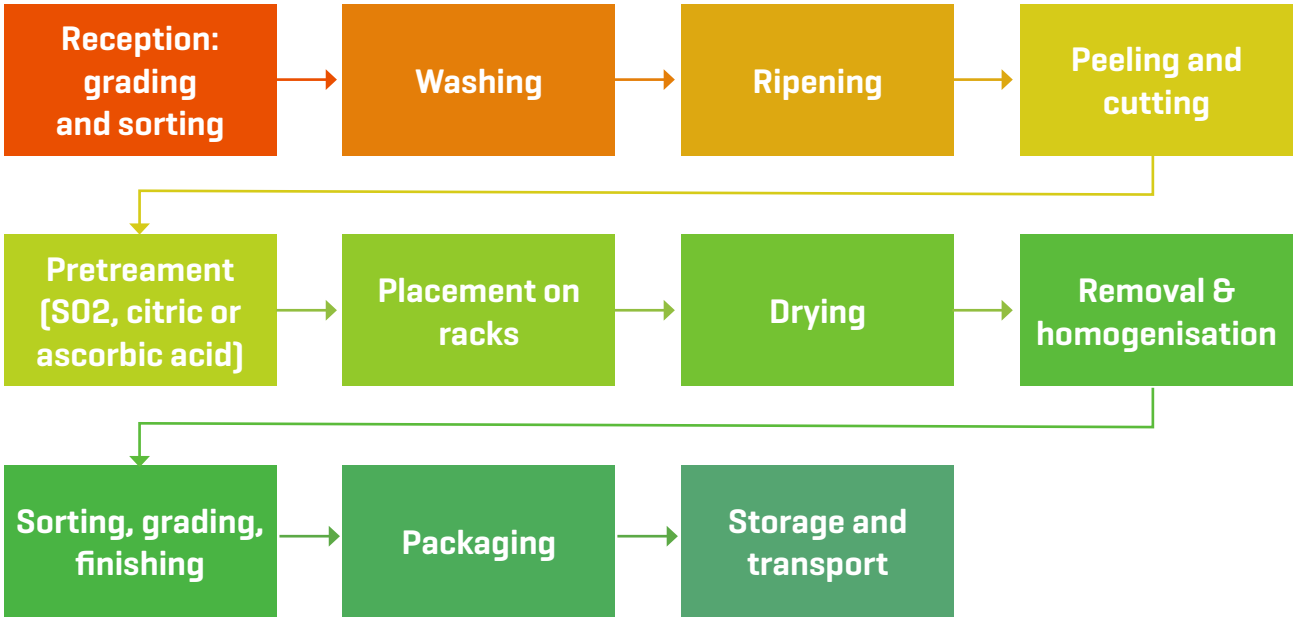
Figure 10. Moisture analyser

An important part of quality control is the moisture analysis of the final product. Ideally, a few samples of each drying batch should be tested to ensure the moisture level is according to the customer's specification. The trick is to get as close as possible to the maximum moisture level specified by the client. This enables the mango processing company to essentially sell more water and spend less energy on removing moisture. For example, 250 kg of dried mango at a moisture level of 16% only weighs 241.50 kg if the moisture level is reduced to 15%. At a sales price of €7/kg, this means a loss of €59.60 in sales revenue. Furthermore, the product is likely to get drier as it is stored, so if it is already at the bottom of the range when it leaves the factory it may end up being too dry by the time a consumer eats it. A moisture analyser is a simple device that can be used in the factory to check levels (see Figure 10).

3.3.7 Storage and transport

Storage and transport should take place under refrigeration, particularly for small factories that can take weeks to fill an export container. The lower the temperature, the better the product will look after export. Dried mango is normally exported in refrigerated 40-foot containers, that hold 20–21 tonnes.

Figure 11. Flow chart of successive stages in mango drying for an agent running a processing plant



3.3.8 Common issues with drying mango

The attention to detail needed to produce a quality product means that some troubleshooting could be needed. Table 3 presents an overview of common issues faced when drying mango and what the potential cause could be. This will assist in finding remedies to these problems.

Table 3. Common issues with drying mango

Common drying problems	Causes
White spots or strips	Not peeling deep enough – the pieces of skin will turn white.
Brown or too dark	Overripe fruit, long drying time, high drying temperature, bad-quality drying, fruit exposed to air between cutting and drying.
Too dry and chewy	Drying time too long, slices too small or thin, fibrous variety.
Hard outer layer soft inside (case hardening)	Pieces are too big, drying is taking too long, and the temperature is too high.
Soft/mushy product	Pieces are too large, drying time is too short.
Large variations in dryness, colour, flavour in a batch	Fruit is not uniform (e.g. different types), the cut is not consistent, the ripeness is not uniform, or the temperature and air circulation in the dryer are uneven. Perhaps the carts should be rearranging halfway through drying.
Drying cycle takes too long	Too much fresh fruit in the dryer, improper fruit spacing, insufficient airflow, too little heat.

3.4 Technology

3.4.1 Introduction

Large parts of the production process remain manual. In the past, 90% of the focus has been on the dryers themselves. However, at each step there are tools and equipment to help improve product quality and labour productivity. In this section we discuss the necessary equipment at each step.

3.4.2 Washing and sorting

Though washing can be done by hand, it requires an enormous amount of labour. Handwashing also makes it almost impossible to wash and inspect new supplies of fresh mango as they arrive. Factories with a capacity of more than 10 tonnes of fresh fruit per day should invest in an automatic fruit-washing line. A complete line consists of the following parts:

- bulk bin tipper, that can pick up 500 kg/1 m^3 bulk bins and tip this in the washing bath
- stainless steel washing bath
- pump and filter for water circulation
- roller brushes
- elevator that lifts mango onto sorting belt (see Figure 13)
- optional: vibrating table that removes access moisture
- sorting belt with space for 6–10 people with lanes where rejects can be pushed on
- optional: air knife that dries the mango.

Figure 12. Washing mangoes

Figure 13. Elevator that lifts mango for sorting

The typical capacity of one line is 5 tonnes per hour. If more capacity is needed a second line should be purchased that can be installed in parallel; otherwise, the sorters at the end will not keep up. Two lines also allow batches to be processed separately. The line should have variable speed motors so the speed can be adjusted.

There are many suppliers in Asia, but they tend to offer loose machines that have different capacities and speeds rather than integrated lines. South Africa and Europe are common suppliers. A complete line costs from €30,000 to €45,000, excluding installation.

3.4.3 Ripening crates and rooms

Larger factories should consider stackable bulk bins for the transport, storage and ripening of fruit. A forklift is needed to work with bulk bins. Alternatively, small harvesting crates can be

used also with pallet jacks. The disadvantage of smaller crates is the labour used in moving them around. Furthermore, they tend to last only 3 years.

The simplest and easiest form of a controlled ripening room is a shipping container, in which mango is stacked in crates. A fan can be added in. A more advanced version would be a reefer container that has fans and cooling that can be switched on if there is too much ripe mango. The next step are rooms insulated with iso panels and with fans installed. Again, cooling can be added. The next step up would be the installation of humidity sensors and humidifiers, as well as automatic temperature controls. Finally, the most advanced ripening rooms also control CO_2 in the atmosphere and can add ethylene (ethene).

The ideal size of a ripening room is about a 20- to 40-foot container. This allows batches to be kept and managed separately.

3.4.4 Refractometers and ripeness cards

Good factories measure the ripeness of fruit as it comes in from farms, and when it gets released to the production floor. Refractometers are used for this, in addition to internal ripeness charts. For most fruits the outside does not give a good indication of ripeness. The mango needs to be cut and compared to various charts. Each variety will have a different chart.

Figure 14. Refractometers

Refractometers measure the sugar content of fruit, syrups, juices and other food products. The measuring unit for sugar content is Brix, which is the grams of sugar per 100 grams of product. In other words, mango of 17 Brix has 17 grams of sugar per 100 grams of mango. Refractometers require a solution to be made with a liquid to measure sugar content.

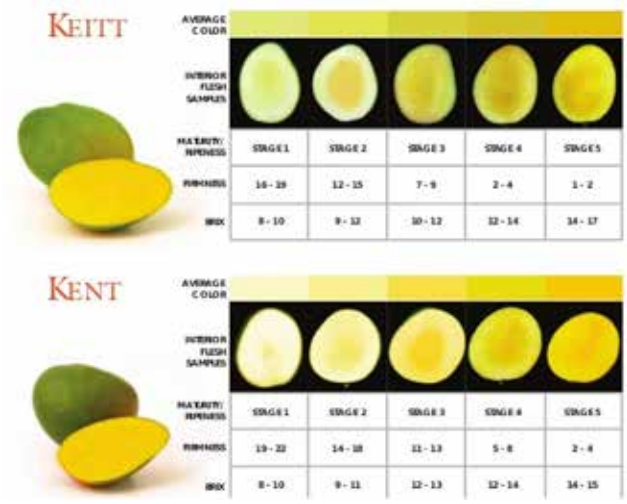


Figure 15. Keitt and Kent variety ripeness charts

In mango drying and fresh mango export, refractometers are used to estimate the ripeness of the fruit before drying or export. Fresh mangoes need to have a low Brix of about 6 for it to be able to ripen after harvest, but provide a 30-day life so that it can be exported and distributed to shops. For mango drying and juice production, you want ripe fruit that has a lot of flavour and relatively low acidity, but is still firm. This means the fruit usually needs to be between 14 and 18 Brix.

There are two types of refractometers, analogue and digital. They also differ in the range they can measure. For mango drying and fresh export, you need refractometers that can measure a range of 1–20 Brix. If you want to work with juice, this is still suitable unless

you want to concentrate juice or add sugar. Concentrated juice can be as sweet as 64 Brix. Normally, the bigger the range that can be measured, the more expensive the refractometer is. An analogue refractometer costs around €150, digital refractometers are easier to use but more expensive, and cost about €450.

Figure 16. Analogue refractometer

Figure 17. Digital refractometer

3.4.5 Peeling, cutting, pre-treatment of mango and loading on trays

For this part of the factory, stainless steel tables that are easy to clean are essential. For hand cutting, stainless steel knifes are important, while peelers are needed for peeling. As mentioned above, the use of automatic peeling machines for mango is not yet economic in developing countries.

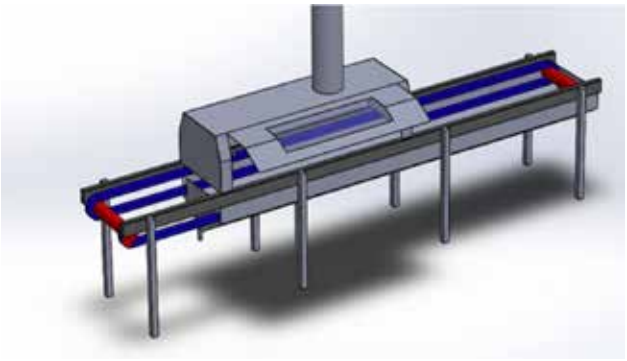


Figure 18. Spraying machine

For treatment with metabisulphite or other preservatives, a spraying machine is recommended, but simple dipping baths can also be used in well-ventilated areas.

Producers should consider the use of automatic dosing and weighing systems that distribute the same amount of mango per drying tray to avoid overloading, and automatically measure how many mango slices have been obtained from the ripened mango released to the plant.

3.4.6 Storage

A storeroom, ideally chilled, is essential for storing the product while you prepare to ship a container's worth. The size of the storeroom depends on the volume of production per week, how long it takes to fill a container for shipping, whether clients require product to be held for some time to send samples from each batch, etc. As a result, larger companies might need a bigger storeroom, but the increase in size is not directly linear. If they are expert at dispatch and have established relationships, they will manage with a smaller storeroom.

3.4.7 Nitrogen-flushing equipment

Nitrogen flushing can be done prior to sealing in bags for weighing and dispatch. If the company is using a automated form-fill-and-seal machine to form the bags, fill them and seal them, then the nitrogen flushing unit can be integrated into the equipment. Should the company be using manual hot-sealing with a pedal push, then a manual nitrogen-flushing machine can be used after the initial sealing.

Figure 19. Form-fill-and-seal machine using a nitrogen flusher

3.4.8 Platform scale

A simple platform scale can be used to measure the weight of bags ready for shipping. This is an industrial scale that is made of stainless steel for easy cleaning. It allows for the larger bags of mango to be placed on the platform and weighed. A digital scale is recommended.

Figure 20. Simple digital platform scale

3.4.9 Mango dryers

Professionally well-built equipment is an important ingredient for producing a consistently high quality of dried mango. This requires that investors understand what makes a good industrial dryer, and the advantage and disadvantages of different types of dryers.

What makes a good industrial dryer?

1. A steady supply of heat with automatic temperature control, determined by measurements being taken in the dryer.
2. Ability to control the airflow into and out of the dryer, depending on the air humidity measured in the dryer. Tunnel dryers can choose to recirculate air or replace it with fresh air. You lose heat (energy) and moisture as you let new air in and old air out. However, saturated air cannot absorb more moisture and slows the drying process.
3. Dryers should be made from materials that are non-flammable, easy to clean and have a low risk of releasing parts on the dried product. Stainless steel, iso panels and food-grade plastics are preferred. Wood on the other hand has several problems: it is difficult to clean, it can release splinters as it wears out and it is highly flammable. In addition, plywood can release chemicals from the glue as it is heated.
4. Strong airflow from dependable electric fans. These encourage an even distribution of air throughout the dryer and around each piece of fruit. Airflow is even more important than temperature in drying.
5. Drying racks need to be open for the best airflow, but they also need to be portable and simple to clean.
6. The size needs to be efficient but manageable. Large dryers may reduce the investment capital per tonne of production capacity, but the larger the dryer, the more difficult it is to fill in a short space of time.

Different types of mango dryers

Solar dryer

Gas or electric dryer

Cabinet dryer

Tunnel dryer

Figure 21. Different types of mango dryers

There are many different types of dryers available. However, the tunnel dryer using heat exchangers in combination with a biomass boiler is emerging as a clear winner. Nevertheless, it is useful to get a good sense of the differences, advantages and disadvantages. These are listed in Table 4.

Advantages and disadvantages for various common mango dryers

Table 4. Advantages and disadvantages of varieties of mango dryers

Type	Description	Advantages	Disadvantages	Recommendation
Open air drying	– Product is placed in racks or tables in the sun in the open air	– No energy cost – Very low investment cost	– Only works in climates that are dry and hot at the time of harvest – If rains come unexpectedly, all the product needs to be covered or brought inside – Does not work for fruits that brown easily – Irregular production capacity – Can be contaminated with dirt, dust, foreign matter and Salmonella due to wind	– Not recommended for mango, since the product browns easily and is usually harvested in the rainy season
Solar dryers	– Table covered by plastic that is placed in the sun – Can be as large as a converted greenhouse – Average cost: €250–400	– Cheaper to build that artisanal gas or tunnel dryers – Low energy cost – Works in smaller production batches	– No sun means no drying, so does not work at night or during the wet season – Every production day is unique, and every product is unique – Planning a business is challenging: When will you require labour? When will the product be ready for the customer? – Final product is not likely to be good, due to stop–start drying and fluctuations in temperature – Dryer has low production capacity for a high investment cost – Savings are minimal because only a small portion of your costs go towards heating, and air flow still requires electricity – Cost of inefficient production likely much higher than energy savings	– Unless you work in an area/season with reliable hot and dry weather it is not suitable for industrial production – Can work for small companies that occasionally sell small quantities of fruit
Classic artisanal gas (Atesta)	– Simple dryer manufactured by local artisans with local material, usually wood – Uses a basic bottom gas burner or electric coil – Capacity: 200 kg of fresh fruit – Energy use: 0.7 kg of gas per 1 kg of finished product – Average cost of dryer: Not relevant as this has gradually been replaced by the improved Atesta	– Cheaper to build than the improved Atesta or tunnel dryers – Can be made from local material by local artisans – Works in smaller production batches – Reasonably reliable – Can be repaired easily – Small size makes management easy and gradual expansion possible	– Each dryer is slightly different, so how do you get consistent product from several dryers? – Higher percentage of second grade final product – Low production capacity – Not very energy efficient – Can never be HACCP certified – Lack of ventilation means uneven drying; racks need to be turned every 2 hours – costs a lot of labour and loses heat – Dangerous: Each year at least 2 factories with wooden dryers burn down to the ground in West Africa – Dryer uses wire with nets on top that need to be washed after each cycle	– Do not purchase anymore, rather go for improved version
Improved Atesta	– Has a simple extraction fan added that creates air circulation – Some have temperature gauges – Energy use: 0.7 kg of gas per 1 kg of finished product, plus additional electricity for powering the electric fan – Cost: €4,000 (stainless steel, 240 kg in 20 hours)	– Quicker drying times – Better product quality – Less second grade – More homogenous product	– Most disadvantages of Atesta are still valid	– Good way to start gaining experience, but unsuitable for industrial production for premium export markets

Type	Description	Advantages	Disadvantages	Recommendation
Modern cabinet dryer	– Industrially manufactured stainless steel dryers with removable trays – Compact design – Usually only 1 or 2 stacks of racks next to each other – Capacity varies from 200 to 500 kg fresh fruit – Can work with electricity or heat exchanger with steam/ hot water – Energy use: There are various quality standards and origins; however, a cabinet dryer from Gemtech, India that dries 700 kg of wet mango per drying cycle of 20–24 hours uses 6.5 kw/h – Cost: €40,000	– Usually cheaper and smaller than tunnels – Constant production of good-quality product – Works in smaller production batches – Easy to expand – Reasonably reliable – Can be HACCP certified	– Capacity smaller than tunnel dryers – Ventilation usually not as good as with tunnel dryer – More difficult to load, unload and move product (no trolleys)	– Can be a good dryer for a smaller factory, but always compare capacity versus cost with tunnel dryers

3. Supply

Type	Description	Advantages	Disadvantages	Recommendation
Tunnel dryer, stand-alone	– Industrially manufactured dryer, with large industrial electric fans on 3-phase, heat exchanger or industrial intermittent burner, separate electrical control panel, automatic temperature control, and preset drying programmes – Dryer is built from iso panels inside the factory – Energy use: 2 kw/h per kg of dried mango; 0.4 kg of gas per kg of dried mango Cost: €50,000	– Good airflow: Air is forced through the racks and trolleys by powerful fans leading to more uniform drying, and eliminates the need to change racks completely or reduces it to once per cycle – Automatic temperature control avoids burning of the mango – Halves the usage of gas, or eliminates this completely if you opt for alternative energy sources – Reduces the amount of second grade product – More homogeneous product at higher quality – Good capacity: Accommodates 4 to 8 trolleys with racks standing 2 wide and behind each other; normally 220 kg of dried product is produced per 16–24 hour drying cycle – Food safe: Uses iso panels and stainless steel, which are food grade – Allows for multiple sources of heating – both direct and indirect; gas, electricity and biogas, wood, cashew shells, rice husks, or other fuels can all technically be used – Stackable plastic racks on trolleys are easy to work with and clean – Easy to disassemble and move elsewhere in the plant or to new factory	– Higher investment cost – Large, and thus requires well-organised workforce to fill before the first mango browns, whereas small dryers are easy to fill – Smaller dryers than 1,500 kg are available, but tend to be much more expensive per kg capacity; a dryer half the size is still ¾ of the price of a large one – Technically more complex, takes longer to learn to work with them – Control units are sensitive to power surges, and need to be properly protected with stabilisers – Generator is essential to provide power in case of electricity cut; otherwise, the load is lost – 3-phase electrical connection is required	– The best and some would argue the only serious option for modern drying plants – – Biomass can be used to power these tunnels – there are some obvious benefits in reducing cost as well as an opportunity to reduce the risk of contamination from gas coming into contact with the drying mango pieces – – However, this option requires excellent control of the waste needed to power the equipment; this is typically only feasible for well-organised, professional plants that can arrange consistent access to various waste streams (e.g. cashew shells, cocoa husks) throughout the processing season and can manage the waste so that it does not affect air quality and odour, ripening programmes, HACCP, food safety, and health and safety of staff in general; there are consequently relatively few successful examples of biomass-fired dryers outside of heavily industrial plants such as HPW in Ghana. It is also only really economically feasible for factories processing about 750 kg of dried mango per day i.e. 3 tunnel driers

Type	Description	Advantages	Disadvantages	Recommendation
Tunnel dryer, container based	– As above	– Container-based version is easy to install, and can be placed outside the factory on a concrete platform – Can save factory space if existing factory is small and quick solution needs to be found	– A crane is needed to move and install the equipment, which is essentially 3 intact containers plus drying shelves; this requires organised, skilled installation – Though in theory plug-and-play, they do not save much time on installation because most parts still need to be installed on the spot – Though it can be placed outside, once the cost for the concrete platform, the container itself and the transport is added you probably do not save much – Container-based tunnel driers are shipped as containers; consequently, their transport costs are higher than stand-alone containers – for example, if 3 container driers are bought, shipping costs are incurred for each container; the panels and racks for 3 stand-alone containers can be shipped in one 40-foot container	Recommended only if one wants to use an existing factory building that has limited space

Energy sources for mango drying

- Direct heating: gas burner, electric coil, or radiator as the dryer's heat source
- Indirect heating: heat is used to heat water or steam, which is then used to heat the dryer using a heat exchanger.

Table 5. Energy sources for mango drying

Energy	Advantage	Disadvantage
Solar	– Cheap	– Unreliable, does not work at night, seasonal, different temperature and drying time all the time
Electricity	– Easy and cheap to install in dryers	– Unreliable due to the regular power outages in several countries – Expensive
Gas: direct	– Very reliable – Reasonably efficient and affordable – Suitable for small and large dryers	– More challenging to maintain and repair than electric – Direct contact causes a bit more browning – Requires stock of gas bottles and special storage
Gas: indirect (heating hot water)	– Reliable, great control over product quality	– Less efficient and more expensive
Coal: indirect	– Cheap and reliable, great control	– Typically, unavailable in many parts of Africa
Biomass: indirect	– Cheap and reliable, great control over the drying process, best product quality	– Only works with sustainable supply of cheap biomass located nearby – Higher investment than gas burners; heat exchangers are comparable to burners, and the boiler and piping is an added cost – Only feasible if you have 2 large tunnel dryers or more, 6–10 dryers can feed from one boiler

3.4.10 Cold storage, finishing, packaging

Finished product is sorted and conditioned by hand, and this process is difficult to automate. However, packaging can be automated quite easily using a so-called form-fill-and-seal machine. This machine makes plastic bags from rolls of plastic, automatically weighs the right amount of fruit, fills the bag and seals it. There are also machines available that will remove the oxygen and replace it with nitrogen to dramatically increase the shelf life of the product. Suppliers of good-quality packaging machines can be found in Germany, Italy and South Africa. Because there are so many different types one really needs to be advised by the experts from the suppliers what machine to take.

Cold storage is quite easy to construct from the same iso panels used for dryers. Powerful air-conditioner type units are installed to allow for the temperature to be brought down to 5°C if necessary. The Netherlands, Spain and South Africa all have good suppliers.

The easiest equipment to get a detailed estimate for are moisture analysers. A small part of dried fruit or any other product is put on a metal scale inside the machine and weighed. Then, using a heat lamp or heating element, the sample is heated until all the water has evaporated. When the weight is no longer changing, this weight is then compared with the starting weight to calculate the original moisture content. For example, if the original sample weighed 50 grams, and after drying there is 45 grams left, the moisture content of the sample was 5/50 = 10%. Moisture analysers normally have a range of different drying programmes.

Moisture analysers cost between €950 and €1,500, depending on the brand and how versatile the machine is. They can be purchased from suppliers of laboratory equipment.

Figure 22. Moisture analysers

3.5 Ingredients for success

This section contains several key ingredients for success in the dried mango business, and they tend to be interrelated.

3.5.1 Availability of raw material and a sourcing strategy

First, you can only enter the mango drying business if you have access to large amounts of the right mango at affordable prices. You can afford to pay up to about €0.22 per kg of mango if you need 13 kg of fresh mango for 1 kg of dried product and still make a good profit.

The varieties need to be fibreless or low in fibre, have a good mango flavour with a combination of acidity and sweetness, and produce a pleasant yellow to light orange colour when dried. Preferably the fruit size is large with a good pip-to-flesh ratio.

You also need a production season of at least 3 months if you can produce other products, or 4 months if you can only produce dried mango. This means you need to work with 3–4 different varieties to stretch the season.

Though the timing of the season is not critical, it is an advantage if your season is different from those of competitors since importers prefer to source product year-round. This means it is an advantage if you fall outside of the January–July window.

Finally, to export directly and operate a modern plant that can be HACCP, BRC and/or ISO certified you need to be able to source about 30 tonnes of fresh mango every day consistently throughout the season.

3.5.2 Right location of the factory

Because you need at least 13 kg of fresh material for 1 kg of dried material, and transport degrades fresh fruit quality, you need to be within 5–6 hours' drive by truck from your orchards, or a few hundred kilometres maximum. Otherwise, the transport cost will be too high, as will be the losses during transport. The further you are away from farmers, the more difficult it is to maintain relationships and to refuse loads of poor quality. In fact, if you are a few hours from orchards, you will need sourcing agents on the spot to do the first quality check in the field.

Second, the factory should preferably be located on an industrial zone with access to 3-phase electricity supply. It is common for factories to start production in a rural area just outside a village or town. However, within a few years such a factory tends to get surrounded by houses. This not only reduces the possibility to expand, but it also leads to narrow access roads and neighbours who complain about noise and smells.

Third, factories need to be in a location that containers can be transported to. The closer to a major port the better, since the driving force in export cost is the distance overland to port. Sea freight prices tend to be similar to most destinations.

3.5.3 Product diversification potential

It is very difficult to create a profitable plant if it can only work 3–4 months of the year and is dependent on one product. This can only work if the fresh mango is relatively cheap.

To export and be profitable, a factory needs to employ a well-educated and capable management team. However, good professionals tend to get bored if the factory is closed for most of the year. Moreover, the overhead of their salaries is difficult to cover with one product. Investments in equipment, buildings and certification are also difficult to recover with one product.

Customers also prefer to source a range of products from the same supplier to economise on the number of suppliers they need to manage. Finally, if you only produce mango and the season is bad, the whole year is bad.

The easiest way to diversify is by drying other fruits, such as pineapple, coconut and banana. However, these are not always available at affordable prices in mango areas. The next step is to look at other vegetables, herbs and spices, grains, etc., that also require drying.

When assessing the potential for diversification it is important to realise that not all products will be as profitable as dried mango. You may have to accept that a particular product has a lower margin, but it covers the cost.

3.5.4 A capable management team

A professional business requires a financial manager, an English-speaking marketing and logistics manager, a factory manager, a sourcing manager and a CEO. Most exporters try to save on marketing staff, while the main reason for exporters not to buy is the fact they do not feel comfortable working with people who do not speak English. Other practices to avoid are employing unqualified family members and inexperienced staff to save on salaries.

3.5.5 Scale

For a modern plant to be able to invest in machinery, good staff, marketing, certification and to be able to export directly it needs to produce a minimum of 150 tonnes of dried mango per year, preferably 250 tonnes. This is equal to working about 3.5 months with 6–10 tunnel dryers that each provide about 240 kg of dried mango per day. The amount of fresh mango needed for this is about 2,000 to 3,500 tonnes.

Importers want to work with only a few trusted suppliers, who can supply them with multiple containers each year. Each new supplier they need to take on requires more paperwork, coordination and site visits, for which they do not have the time or money. Hence, to sell you need to be able to supply at least 3–5 containers to a client per year.

Businesses that want to export to other countries must either grow themselves or learn how to source finished goods from smaller local suppliers. Alternatively, smaller processors could consider building relationships with larger exporters who might be looking for additional volumes. These might be in your country, or in the region.

3.5.6 Efficient production and knowing the cost price

You can only make money if you can manage to produce a high-quality product efficiently. This means you need a very efficient factory layout, good-quality equipment, well-trained staff and good-quality raw material. It also requires continuous recording of the production, and analysis. A good factory weighs product and rejects at each step (reception, ripening, cutting and peeling, drying, packaging) so that they know exactly where they lose money.

A good entrepreneur also knows their cost price and manages cost on a continuous basis.

3.5.7 Certification

HACCP is a minimum to be able to sell product on the European market, but BRC or ISO 22000 are important as they can open new markets. The most difficult part of certification is the paperwork and training. Organic certification is important for organic clients, but does not tell anything about the quality and safety of your production process. Fair trade can open certain niche markets but is not that important.

3.6 Issues and opportunities summary

Table 6. Issues and opportunities

Issues	Opportunities
– Technically demanding – Competition from frozen fruit – Carbon footprint – Regional sourcing increases costs and complexity	– Few competitors – Technical barriers to entry – Regional sourcing to fill in an annual supply calendar – Waste conversion to maximise value

3 MANGO PURÉE

This chapter has been developed by the Fit For Market + and Fit For Market SPS programmes, implemented by COLEAD within the framework of the Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union (EU).

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Contents

1. What is mango purée?

Mango purée is a pulp that is created by squeezing ripe mangoes. The fibre is broken down somewhat and the skins and pips are removed. The final product is a thick purée that is already a concentrate and is frequently shipped without further concentration. To produce a drinkable mango juice, water or juice must be added. However, the purée is also used in a variety of other food products such as ice creams, yoghurt and baby foods.

Mango is different from most other fruits, which tend to separate into solids and liquids when pressed. The juice of mango can be consumed without adding other products. Sometimes a portion of the fibres are added back in the juice later.

Figure 1. Bowl of mango purée

Fruit juices and mango purée are often concentrated through a process of evaporation to reduce transport and storage costs. Later, bottlers of juices will add water back in. They may also add a small amount of concentrate to a juice blend. And they can add concentrate to carbonated water to make fruit-flavoured fizzy drinks. Juice itself cannot be carbonated, so concentrate is needed to give an intense fruit flavour.

The disadvantage of concentration is that volatile flavours and aromas are lost when the product is heated to evaporate the water. However, there are flavour-recovery units that capture these aromas, which can then be either added back into the product or sold as a separate product. Furthermore, in markets where consumers are less sensitive about added flavours, artificial aromas can be added to increase the flavour.

Unconcentrated mango purée or juices are called "single strength". Concentrated mango purée is often sold as double or triple strength. However, there is no clear definition of what double or triple strength is. The objective standard to indicate the strength of any concentrate is degrees Brix (symbol °Bx), which is the sugar content of fluid. One-degree Brix is 1 gram of sucrose in 100 grams of solution. In the industry this is referred to simply as Brix.

Single strength mango is somewhere between 14 and 18 Brix, double strength is often 22 to 24 Brix and triple strength is around 28 Brix – although it is called triple strength it has only double the sugars.

The Brix of a purée is not only determined by the amount of water that is evaporated, but also by the variety of mango and the growing conditions (soil, sun, etc.). For example, the standard for a single strength purée is 14–18 Brix. Varieties such as Totapuri from India may have only 14 Brix, and Kent or Keitt from South Africa 16 Brix. Mango in West Africa can easily reach 17 to 18 Brix. The higher the Brix, the stronger the purée is perceived to be and the more valuable the product is. However, as mentioned concentration does lead to a loss of certain aromas.

1 What is mango purée?

Each juice has in fact its own standard, and most juices are between 12 and 14 Brix single strength. For pineapple the most popular format seems to be triple concentrate or strength, while orange juice is often more than five times concentrated from 12 Brix to 58 or 60 Brix.

Mango pulp can be packaged and sold in two forms, aseptic and frozen, of which aseptic is the dominant form. Aseptic is much cheaper to store and transport, because no cold chain is needed. Both come in 210-litre drums. Aseptic pulp is sterilised using heat (steam) to kill all bacteria and spores, and packaged under sterile conditions in a sterile bag in a steel drum. It is stable at room temperature and does not need to be transported in refrigerated containers or stored in refrigeration. In contrast, frozen pulp is flash heated, but at significantly lower temperatures than the aseptic product. This enables the product to be pasteurised at a later point in the production process without altering its colour[1] and retaining many of the volatile aromas and flavours. This is especially needed in the dairy industry.

1 Undergoing a second pasteurisation often results in a discoloration of the product to a greenish hue.

2. Demand

2.1 Overview of the juice market and general trends

The global juice concentrate and pulp market is valued at US$400 million and is expected to achieve only 5.7% growth in value between 2016 and 2026. North America, Western Europe, Asia and Australasia dominate fruit juice and nectar volumes, with North America and Western Europe accounting for nearly half of the total market (see Figure 2).

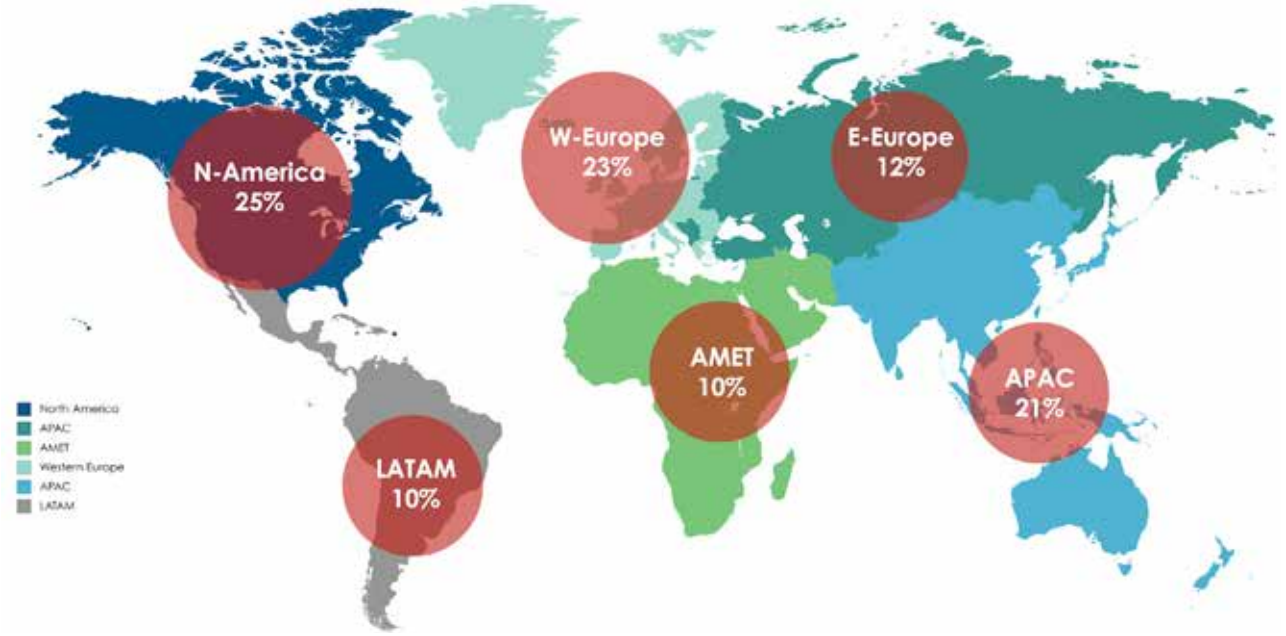

Figure 2. Breakdown of juice consumption in the world 2016. Source: AIJN (2018)

The European juice market is currently largely ambient stable juice (75%) sold in cartons and bottles kept on regular shelves, and 25% chilled juice kept in fridges. However, many juices sold in fridges are ambient stable. They are placed in fridges to give the appearance of fresh juice.

Of all juice (fridge and ambient), 66% is made from concentrates and 34% from fresh juice. About 65% of all juice is in fact a 100% fruit juice, while 35% are nectars, which are fruit juice with water, sugar and other ingredients added. The USA follows similar trends.

However, consumers are increasingly on the lookout for healthier foods, snacks and beverages. They have become increasingly concerned by the sugar content of juices as well the use of concentrates and added flavours, preservatives, etc. As a result, the traditional juice market in Europe and the USA is declining both in volume and value, and these declines are expected to continue.

Many consumers are looking for healthier alternatives and their expectations and buying behaviour have been changing. For this group "all natural" (no sugar or flavour added), juice is mandatory, with many opting for juice that is "not from concentrate" (NFC) (known as *"Direktsaft"* in Germany, the largest European juice market). Organic is also important among this group of consumers.

As a result, pockets of growth exist in the declining juice market. These help to compensate for the lost volumes from people who no longer buy juice or simply drink less of it. The growing segments are "not from concentrate" chilled juices. However, the traditional juice market remains sizable. Within this market in Europe specifically, private label (juice sold under supermarket brand) is also on the increase. This is part of a wider trend where consumers are becoming more price sensitive. This is partly driven by the growth of discount supermarkets such as Aldi and Lidl.

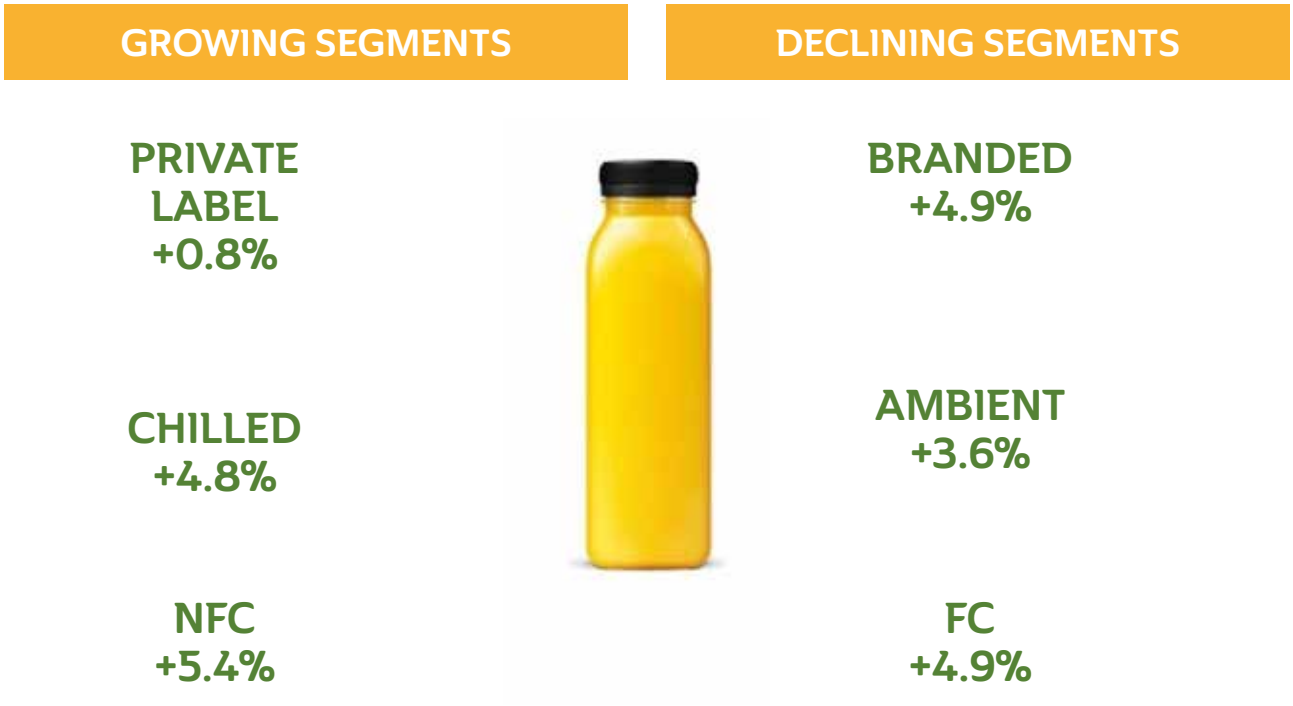

Figure 3. Growing and declining segments in the European juice market, 2016
Source: AIJN (2018)

Although it is widely believed that smoothies are still a fast-growing market, their growth in stores seems to have stagnated according to most importers and experts. As one juice company said, "Whenever we see a new smoothie brand, we wait for it to go bust." However, it is quite possible that people make more smoothies at home, which would explain the growing presence of frozen berries and mango in supermarkets.

According to some experts there are two segments in most juice markets: a huge but declining number of consumers who just want nice-tasting juice and are less concerned with sugar and preservatives, and a premium segment that wants a clean label, natural juice.

To respond to consumers who are concerned about consuming sugary drinks, many manufacturers have begun to explore fruity beverages as innovation routes. Fruity waters or fruit splashes, fruity beers, fruit-flavoured dairy drinks, etc., have all seen substantial growth. This has in some measure compensated for the declines in the beverages market. As result, while fruit juices have declined in volume, imports of fruit pulps to Europe and USA have remained stable.

Figure 4. Fruity beverages

There are many competitors in the declining juice market. It is not unusual for a single market to have many brands on offer, with a wide range of products. Global players such as Coca-Cola and Pepsico, regional juice players such as Granini, local heroes such as Riedel in the Netherlands and very aggressive private label manufacturers such as Refresco are all common competitors in a single market.

This intense competition has meant that brands have had to look for differentiation to stay ahead. Innovation has become an important tool for manufacturers, who have consequently experimented with a wide range of new product introductions. They have tried functional benefit claims (e.g. "for energy"), quality claims (e.g. cold pressed juices), new product formats (e.g. smoothies), as well as packaging and ingredient innovation. Many have attempted to differentiate themselves from their competition by bringing new flavours to the category. As a result, tropical fruit flavours have become a core part of the flavour line-up for many brands and sit alongside berry, apple and pear as firm favourites.

In Germany in particular, mango and maracuja (a type of passion fruit), seem to be "on-trend" and a flavour combination that extends to tea, lotions, hand soaps, etc. This innovation grew the exotic fruit juice and pulp trade to US$400 million globally in 2017 and is expected to grow at a fair pace until 2026.

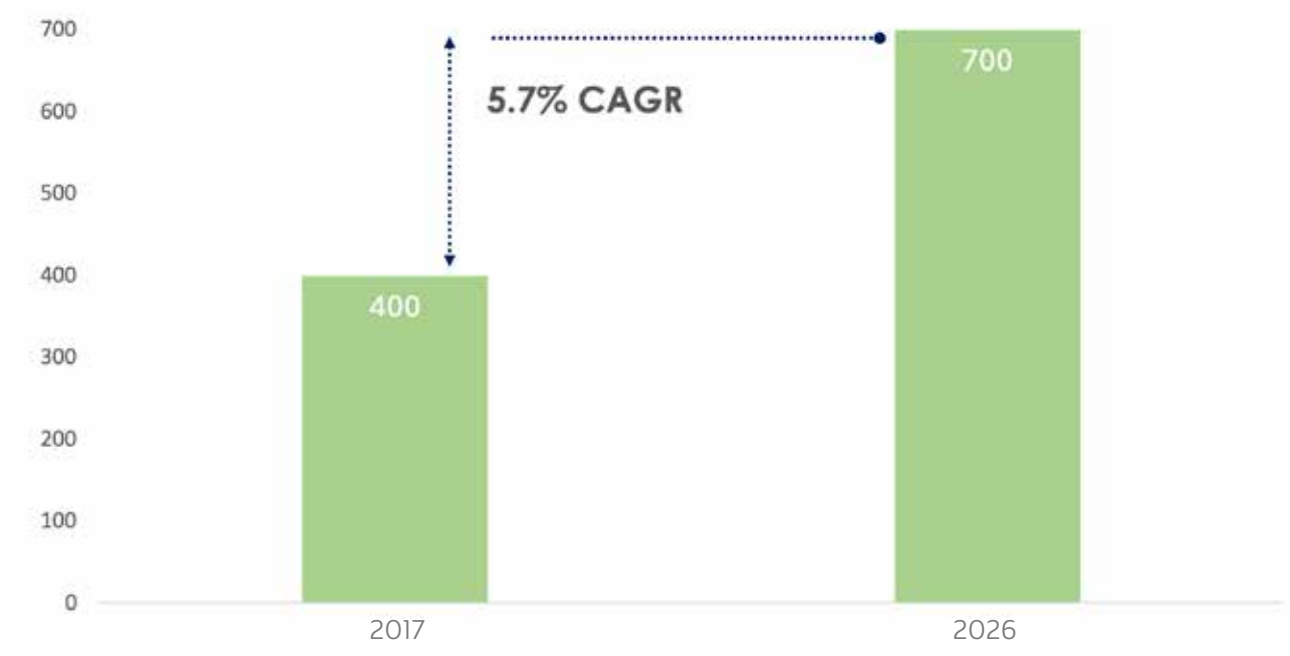

Figure 5. Exotic fruit drinks – actual and projected market size

In conclusion, mango is a growing market segment in the declining juice market.

2.2 Other uses of mango purée and concentrates

Mango purée has many other uses beyond the juice market. It is used industrially as an ingredient in ice cream, smooth yoghurts, smoothies, baby foods and jams, and as a sweetener in a wide range of snacks (e.g. snack bars). It is also increasingly used to add flavour to white vinegar to create premium mango vinegars. Fresh and IQF (individually quick-frozen) mango pieces are relatively expensive. So, using purée allows companies to design mango products that are more affordable.

In more premium products, especially where the texture of mango is needed, IQF cubes are more likely to be used in preference to or alongside purée. Mango purée is very smooth and lacks the texture that is needed in these recipes. Yoghurts where you can see and feel real mango pieces are one example of products that typically include real mango pieces. In this premium product, manufacturers would choose to use IQF mango pieces, which provides a chunky texture, but is easier to handle than fresh mango. Nevertheless, as mango purée is cheaper and easier to work with, this is generally included in the recipes of far more expensive or textured products too. Each company does a cost–benefit analysis and decides on whether purée, IQF cubes or what balance of the two ingredients depending on the desired flavour, texture and end price of the product they are designing. The exact ingredient choice or balance will be a trade secret.

Figure 6 shows a range of products found in US and European supermarkets that contain mango. It is not always possible to see from the outside whether mango purée is used or a preparation based on frozen mango cubes.

Figure 6. Examples of foods prepared with mango purée

2.2.1 The African market

The juice market in Africa is fundamentally different from that of other continents. Consumption of packaged juice is very low, and as such Africa is the last frontier for global juice companies.

From a supply perspective, there are very few industrial bottlers active in Africa. Most juice available is actually imported by traders by the container load. Importing in retail packaging makes the product very expensive. What is imported is usually a brand and product for which there are cheap overstocks available somewhere. This is why there are often changes in the brands available. Some of the more regular brands are imported from South Africa (Ceres) and Spain (Don Simon). Egypt and other countries in the Middle East are also regular suppliers.

Local production in Africa is usually limited to small artisanal producers who purchase first grade fruit, and process this in an artisanal or semi-artisanal way and bottle in second-hand

glass bottles, because they are easy to sterilise and hot fill. Often sugar is added to improve the flavour. Production is seasonal and, because shelf life is limited, sales are also seasonal. Each producer tends to have 3 to 10 different flavours. The distribution of product from these companies tends to be limited to a few shops, restaurants and hotels, and occasionally one or two wholesalers. The production in these companies is also quite small as each company will typically produce somewhere between 50,000 to 100,000 small bottles per year.

This business model has many challenges. First, it is difficult because a juice producer must manage everything from raw material to retail sales. Second, the production is usually limited by the number of second-hand bottles available. Recyclers have limited numbers of bottles to sell, and most juice producers are forced to set up a collection system for second-hand bottles. Third, the packaging cost are usually about 50% of the cost of production, making the product two to four times more expensive than, for example, locally bottled soft drinks. The fact that first grade fruit is used further increases the cost of production.

Juices in Africa, both imported and locally produced artisanal juices, are luxury products and distribution tends to be limited to upmarket conveniences stores, often in petrol stations, and a few supermarkets.

A challenge in the marketing of juices in Africa is that from the perspective of most shoppers fruit-flavoured sodas, juice cordials, nectars and pure fruit juice are quite interchangeable, but anything that is not 100% fruit is much cheaper. Many consumers do not understand the difference between a fruit juice and a nectar, or a drink with artificial flavouring. Part of the reason is that in most countries there are no strict packaging laws that prevent producers using images of fruit on the label if there is no fruit inside, or these laws are not enforced. And many consumers are not able to read and understand labels.

Local soft drinks can be much cheaper because they are basically an artificial flavour blended with water or carbonated water. No pasteurisation is needed, which means it can be cold filled in cheap PET (plastic) bottles. This is feasible on a relatively small scale. Industrial bottlers, on the other hand, often bottling under licence of Coca-Cola or Monarch, have the advantage of scale. An industrial PET or Tetra Pak filling line typically handles 20 million litres per year.

The number of industrial fruit juice bottlers is increasing in Africa, albeit at a slow pace. For example, there are now two bottlers in Burkina Faso, though they combine their businesses with purée export. Senegal has had an industrial bottler, Kirène, for a long time, that has recently opened a new plant in Côte d'Ivoire. In Mozambique, the Portuguese company Compal opened a plant. South Africa and Egypt have had multiple juice bottlers for a long time. Typically, these bottlers import all their juices and concentrates from outside Africa.

2.3 How do juice bottlers use mango purée?

Pure mango juice is not available on European and US markets. Because mango purée has a very thick texture, it needs to be blended with water to produce a drinkable juice, and then sugar needs to be added to improve the flavour. This means it cannot be sold as a juice but needs to be labelled as nectar, which decreases its marketability. Furthermore, mango as a stand-alone flavour is probably too particular for the European market. Mango purée is therefore only used in juice blends.

Juice bottling is in fact the art of blending. Bottlers try to create a great tasting juice at the lowest price, while being able to make interesting claims on the packaging around ingredients that will attract the attention of shoppers. Each juice bottler decides on what to buy based on the cost and the flavour profile they want to achieve with their product.

To manage costs in a fairly price-sensitive market, most companies blend readily available, cheaper juices with a more expensive claimed ingredient. Grape, apple and pear juice are popular base ingredients in juice blends. These ingredients tend to have a neutral flavour. Though it has a more distinct flavour, orange juice is also used as a low-cost base or filler. More expensive ingredients with distinct flavours or an interesting image, such as mango, are used in smaller quantities to add a distinct flavour and spark the interest of consumers. They are always claimed on the pack. In some instances, minute quantities are used, just so the ingredient can be claimed.

Most mango juices on the market contain only between 5% and 20% mango. Mango is frequently blended with orange juice, as well as other tropical juices such as pineapple. Pineapple itself sits somewhere between a cheap base and a claimed ingredient as it is not as expensive as mango.

Companies are constrained by regulatory requirements around claimed ingredients and mandatory ingredient labelling legislation. For example, organic claims must meet European legislation and must ultimately carry the European organic logo. Juice made from concentrate must state this on the pack. Blends of two ingredients must be named on the pack in descending order of contribution to the blend and three or more may be called a "blend of fruits". [2]The ingredients must be indicated on the ingredients list and shown in order of content.

2 https://eur-lex.europa.eu/EN/legal-content/summary/fruit-juices-and-similar-products.html

When it comes to the choice of which and how much mango purée to use, bottlers need to make a trade-off. The stronger the purée (in sugar content or Brix) and the stronger and more pronounced the flavour (mostly determined by variety, but also whether it is single strength or concentrated), the less you need of the product in your blend. For example, bottlers can choose to use 5% of Alfonso variety single strength at US$1,400 or 10% of Totapuri at US$700 to end up with a strong mango flavour. Because of lower transport cost, triple strength will be cheaper to use, but may give less mango flavour.

Another concern when blending is how the flavour can be kept consistent throughout the year. Most shoppers expect the product to taste the same from season to season, and year to year. But fruit is seasonal, and different varieties and countries produce different flavours. Even the same variety from the same origin can taste different from one season to the next. Most bottlers thus work with food ingredients companies to blend varieties and origins so that they can match the flavour profile consistently. This is crucial as significant changes to the ingredients need to be reflected on pack. Making these changes is operationally complex and can be costly.

2.3.1 Buying criteria overview

Variety and Brix are the two most important and objective criteria used to determine the sales price of mango purée. Together, they give a buyer an indication of the colour, flavour and strength of the purée. This then affects how much purée is needed in the mix. The variety is an especially important factor in final flavour as it affects sugar content, aroma, flavour and colour. So, variety is often used as an indicator of the final flavour.

The method of packing also affects demand for the product and the price. Aseptic packing makes for a cheaper, more stable product, but some aromas and flavours can be lost in processing. So, the more expensive frozen purée is sourced by companies looking to make products that need pasteurising in the final stages of production. This is typical of dairy products. The higher flavour intensity and cost of logistics also attracts buyers who are looking to produce a premium product packed with flavour.

Other buying criteria are the certification (see section 2.3.3), the season and the quantity that can be supplied. The minimum quantity is a 40-foot container that holds about 21 tonnes. However, most serious importers want a large number of containers. It is not interesting for them to have many different small suppliers. The season can be of interest, especially if it is different from India.

2.3.2 Variety and prices

All the prices in this section relate to single strength aseptic purée including transport to a port in the US or Europe (i.e. cost and freight, CnF). Frozen purée tends to be more expensive because of the higher transport and storage costs and the different production process. In addition, frozen purée requires special equipment to process it. The price difference is often around US$100 per tonne.

The most common variety in India and on the global market is Totapuri, and this is also the cheapest product on the market. Totapuri sold for around US$550–750 per tonne for conventional single concentrate (August 2022), depending on the season. In a good season, there is no destination in the world that can compete with Totapuri on price. It does not have a particularly interesting or strong flavour and is usually 14–15 Brix. A "triple strength" Totapuri of 28 Brix is double the price of the single strength. Kesar is another Indian variety

that is comparable to Totapuri in terms of price and flavour. More recently, Indian companies have been looking to bring table varieties to market. But these are still being tested on the international market.

Totapuri is mostly used in cheaper juices and food products, and is often sold as a double or triple concentrate to reduce transport costs. It is, to a certain extent, used to be able to claim that a product contains mango. But the lack of flavour means that either more is needed, or an aroma needs to be added (which is more common in the Middle East).

The most expensive mango variety in the world, Alphonso, is still considered to be the gold standard for colour and flavour – there is no other variety that rivals Alphonso. It also comes from India and usually sells for US$1,200–1,600 per tonne. But when there is a bumper harvest, the price can drop to US$1,000, and then it becomes more difficult for other varieties to compete, and thus prices of, for example, Kent and Brooks also fall. These days the market seems to distinguish between Northern Alphonso and Southern Alphonso, which is more aromatic and slightly more expensive.

In-between varieties such as Chato d'Ica (grown in Peru), Palmer (Brazil), Tommy Atkins, Kent and Keitt (Ecuador, Mexico, South Africa), Magdalena (Colombia) and Brooks, Lippens and Amélie (Burkina Faso and Mali) can fetch anything between US$700 and US$1,000 per tonne. For most varieties such as Kent, Keitt, Tommy Atkins and Amelie, single strength will sell at around US$750–850.

Samples are always needed for factories so they can test the strength, colour, flavour and aroma. This is not only determined by the variety, but also by growing conditions (soil, sun, water, orchard maintenance) and processing equipment and management. For example, Kent and Keitt mango in West Africa are said to have a more intense flavour and a higher sugar content than in, for example, Peru and South Africa. However, if the purée is sterilised at excessively high temperatures or for too long, aromas may disappear, the colour gets darker and there may be flavour notes of burned purée.

2.3.3 Certification

Because most purée is used by large bottlers selling to supermarkets, HACCP (hazard analysis and critical control point) certification is essential and considered a minimum. However, IFS, BRC and FSCC 22000[3] (based on ISO 22000 and 22003) are increasingly demanded. There seems to be no real growth in demand for fair trade purée.

Most retailers do not accept processed product that is not certified. And selling uncertified product is a risk. If something is wrong with the product, the bottler needs to pay for all the product to be removed from the shelves and replaced. It is also crucial that if something happens, the bottler can show they tried to manage the risk by working with certified suppliers. HACCP is regarded as the barest minimum, while the others can provide more opportunities.

Organic certification does not say anything about the food safety of a product and is therefore not a replacement for HACCP or BRC. It is, however, important to sell in the growing organic juice market.

2.3.4 Organic market

There is a strong demand for organic purée, and production lags supply. As a result, organic purée can achieve a small, but interesting price premium. It is typically marketed for US$100–150 per tonne more than a medium-quality, conventional purée such as Single Strength Kent. So, if this Kent product is US$1,000 per tonne, then organic Kent will be US$1,100–1,150 per tonne. Entering the market for purée is generally challenging, but those with organic purée are much more likely to find a buyer.

2.3.5 Single versus double and triple strength

The minimum strength for a single-strength purée is 14 Brix, but 15 or 16 Brix is common and considered much better. In West Africa, however, sugar content tends to be higher, often 17–18 Brix. Double strength should have a minimum of 20 Brix, while 28 Brix is often called triple strength.

The main advantage of single strength is flavour, and the fact that it can be used for NFC juices. This is a growing market segment because consumers believe it is healthier and a better product.

The main advantage of double or triple strength pulp is reduced transport costs. A company can in principle make the same amount of juice from one container of 28 Brix purée as from two containers of 14 Brix purée. Assuming the transport cost for a 20-foot container that can take 17 tonnes is US$2,500, this means that the cost savings on 24 tonnes of single strength equivalent purée are US$2,500, or US$73 per tonne. This is a saving of 15% if you would be buying, for example, Totapuri pulp at US$500 per tonne for 14 Brix and US$1,000 for 28 Brix. However, on an Alphonso purée of US$1,400 per tonne for single strength it is not nearly as interesting, particularly because one buys Alphonso because of the better flavour, that then partly disappears if you concentrate it.

3 International Featured Standard, British Retail Consortium and Food SafetySystem Certification 22000.

2.3.6 Shelf life

Frozen purée has a typical shelf life of 18 months. Nevertheless, most buyers prefer product with at least 6 months shelf life remaining. This enables better control of cold chain. This consideration is particularly important for buyers who are looking to use purée in desserts and foods that require a finer texture (e.g. baby food).

Aseptic purée has a typical shelf life of 24 months. It can develop a darker in colour over time. So, most buyers also prefer product that has at least 12 months remaining on the shelf life.

24 Packaging

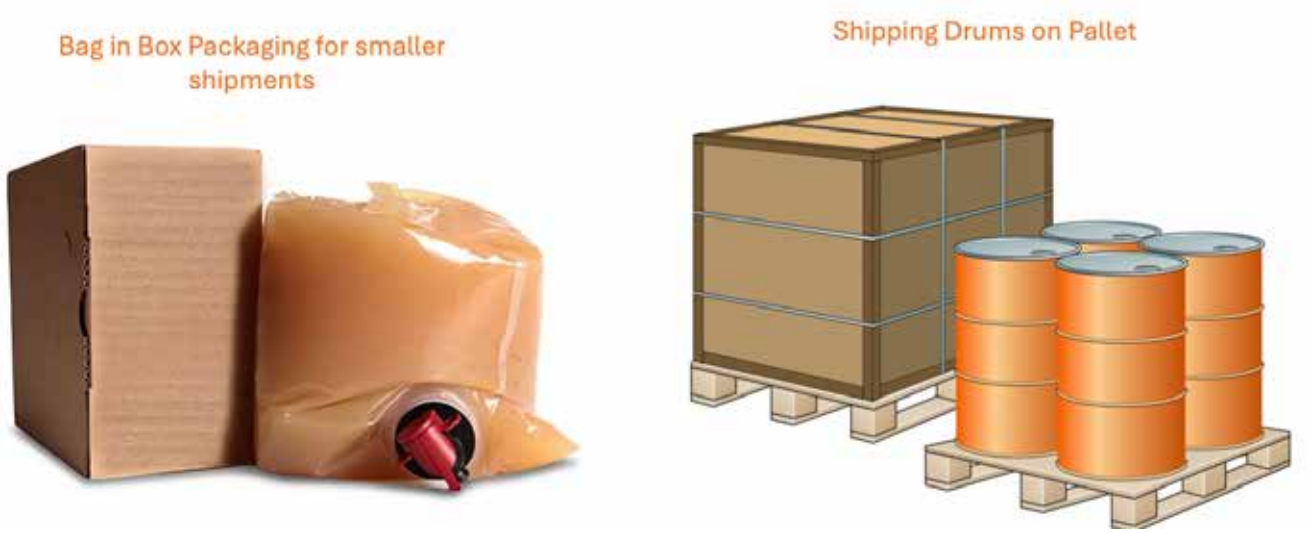

Figure 7. Packaging options for fruit purée
Source: Tetrapak's Orange Book.

Fruit purée and juices and concentrates tend to be shipped in drums that are double lined with plastic sheeting. These are available in 230 kg (215 litre) and 1,000 kg sizes. These are then palletised and shipped. Larger volumes of juice are sometimes shipped using a tanker. Some juices can also be shipped in a bulk bag that fits in a container.

However, for mango the standard seems to be in aseptic bags in a 215 litre metal drum. Because the product is used in smaller volumes, bulk transport is not common. In fact, most bulk transport is used for the bases such as grape, apple and orange juice, as well as for not from concentrate.

For smaller shipments, a smaller box filled with a PET bag is used.

2.5 Market trends

2.5.1 Sugar reduction

Sugar reduction has become a mass trend in developed economies. It is also gaining traction in Africa and other developing markets. The juice sector has paid a heavy price. Nutrition advice now includes recommendations to reduce or remove juice from your diet, especially among those with diabetes or insulin resistance. This has driven declines in the core juice market.

Figure 8. Reduced-sugar drink

2.5.2 Lightly processed

Health-conscious shoppers are increasingly choosing whole foods over processed foods. To them eating an apple is significantly healthier than apple juice. Yet even trend provides opportunities. Some shoppers are content with choosing lightly processed versions of their favourite food and juices. In the case of juices this could be "freshly squeezed juice", "cold pressed", "not from concentrate".

At the same time manufacturers have been working hard to cue that these products are lightly processed and fresh. These types of juices tend to be merchandised in the fridge or in the fruit and vegetable section of the store. In the case of freshly squeezed juices, equipment to squeeze the juice from oranges is in the fruit aisle and this is done on request using oranges from the shelves. Transparent glass and PET bottles might also be used to give a fresher, more transparent feel to the product.

Figure 9. Organic, cold pressed juice, UK

2.5.3 Vegetable juice blends

Several food trends – such as low carbohydrate, whole foods and plant-based ways of eating – emphasise the importance of including vegetables in one's diet. Growing interest here has allowed manufactures to build on a previous trend around juicing. Vegetable juices, which were once a very confusing concept, have moved from being a specialist product to the mainstream.

Today, a range of vegetable juices are included in the blends of mainstream brands. Carrot, beetroot, celery and cucumber are some of the more common flavours. These vegetable purées are also sold on to the food manufacturing sector.

Figure 10. Advertising poster from a leading Dutch juice brand

2.5.4 Local heroes

Shoppers tend to perceive local ingredients as fresher, more wholesome and generally more authentic. So, as manufacturers look to innovate their way out of the declining demand for juices, they are also looking to local flavours and ingredients. In India, turmeric might be added to a recipe. In the UK, this trend plays out with juice manufacturers including elderflower in their recipes. In other countries, this might include claims of local or regional origin. Valencia or Seville orange juice point to EU sourcing origins.

Figure 11. Apple and elderflower juice from Waitrose, UK

2.5.5 Vitality boosting

Health and wellness continues to be an important trend among shoppers around the world. The intense focus on immunity during the COVID-19 pandemic only intensified this trend. Manufacturers have responded by introducing new ingredients that reinforce health and can allow for health or vitality claims. Some innovative concepts include vitamin blends, charcoal, added herbs and spices such as turmeric or ginger and increasingly kombucha.

Figure 12. Fruit Juice Shot from Albert Heijn (AH) Netherlands

2.5.6 Sustainability and ethical standards

Sustainability is of growing importance to juice shoppers and to retailers. This has inspired companies to introduce various sustainable production and business practices. First, companies increasingly opt to use bottles made from recycled plastics . During processing of the juice itself, many companies are working towards zero-waste models, with many attempts to introduce circular production. This is where waste is minimised and they aim to convert waste into valuable products such as compost or biogas. Companies are also striving for ethical production. Many have invested in supporting local communities. Others have invested in membership of the Rainforest Alliance, or in Fair Trade certification – although the second is of decreased popularity in the juice segment. Many companies have opted to make this a part of their brands and have taken this under their own control. Finally, as energy and water are hot topics, several companies are investing in converting to using sustainable energy, reducing their carbon footprints and even in researching farming practices that allow for farmers to reduce the water they need in growing produce.

Figure 13. Billboard from Innocent Drinks UK with recycling message

3. Supply

3.1 How do these products reach the market, what is the structure of the value chain?

The value chain is relatively short, with factories in the tropics generally selling directly to food ingredients companies and specialist juice companies (also known as compound houses). The factories might sell directly to juice bottlers and food manufacturers. In some cases, importers or agents/brokers are involved in linking producers to compound houses or food manufacturers.

Compound houses (also referred to as prep houses in the USA) are importers that store, blend and, in some cases, slightly modify juices and concentrates and can supply natural and artificial aromas. They deliver a standardised product to food manufacturers year-round that can be used as an ingredient in a final product and packaged. Compound houses also help companies develop products that meet their targeted flavour profile, product specifications and the price point, and help with product formulations.

The compound houses often work with several factories in Asia and Latin America, and occasionally in Africa, to have year-round supply and access to different varieties of mango with their own unique flavour profiles. They also order some quantities via importers or brokers, particularly if the products are in short supply or the compound house is asked to source specific products, such as organic or different varieties.

Not every juice or food company uses compound houses. Some companies, usually the larger ones, have a lot of knowledge in-house and are comfortable buying directly from factories with which they have a long-term relationship. They typically secure a large part of their need via contracts and use importers or compound houses if they need more products.

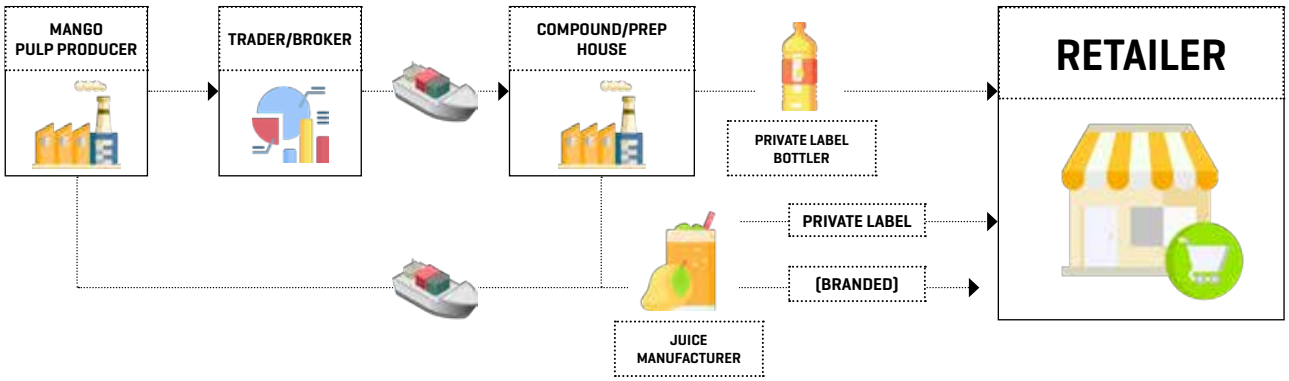

Figure 14. Structure of the pulp/purée market

Since the early 2010s, the industry has experienced concentration, globalisation and vertical integration. Importers and compound houses, food companies and juice companies are merging and increasingly operating globally. Compound houses and importers are also increasingly investing in their own mango purée factories or developing joint ventures or strategic partnerships with open book calculations and long-term contracts. This means the importance of traditional intermediaries such as agents and brokers is decreasing.

These developments also mean that many of the same companies that operate in Europe now also operate in the USA, and the markets are becoming more and more global. Pepsico (Tropicana) and Coca-Cola (Minute Maid, Innocent Smoothies), for example, now have a growing presence across Europe and elsewhere in the world and can be found in every supermarket in Europe. Refresco acquired and merged with about 13 local juice companies across Europe between 1999 and 2016 to become the biggest soft drinks and juice bottler in Europe. In 2018, they bought Cott's bottling activities in North America and the UK, and now have a production capacity of 12 billion litres with 59 facilities in 12 countries.

3.2 Suppliers in the market

The biggest producer of mango purée in the world is India, which has many large factories that churn out 20,000 tonnes per season. It is nearly impossible to beat India on price when they have a good crop. India sells mostly to the Middle East and Europe, though it is also the third largest supplier to the USA.

Mexico is the second biggest producer, and the biggest supplier to the USA. It also operates many large-scale factories. It has been a traditional supplier to southern Europe for a long time, but is starting to become more important across the whole Europe.

Colombia is the second biggest supplier to the USA, but in Europe it is mostly known for specialty varieties such as Magdalena. Its export volumes to the USA have seen strong growth over the past years.

Peru, Ecuador, the Dominican Republic, Brazil, Thailand, the Philippines and South Africa are all producers of mango, but in much smaller quantities than India. Finally, Mali, Senegal and Burkina Faso all have mango purée factories, but the scale is small and export volumes are so modest that most buyers are not aware of them.

3.3 Seasonality

Purée is sourced from various origins around the world. Its longer shelf life allows buyers some flexibility in the timing of when they source purée. However, in general they prefer to source and lock in purchases in line with the global sourcing calendar for the fresh fruit. This provides better control of colour and enables a more predictable supply chain.

As a result, in the earlier parts of the year importers look to source purée from Brazil, Peru, Ecuador and South Africa. Thereafter, in the second quarter the focus moves to Costa Rica. Mali and Burkina Faso are also exporting fresh mango at that time, but they tend not to produce and export purée.

Towards April, Côte d'Ivoire and Mexico begin to export fresh mango. This time of year is on the fringe of the Indian season. Then India comes into production. India exports both fresh mango and purée. This is a major purée production season globally, especially as India produces large volumes of low-cost Totapuri purée. It also supplies Alphonso for about 3 months starting in May.

In the third quarter, Senegal and Israel are exporting fresh mango, before Spain comes into production.

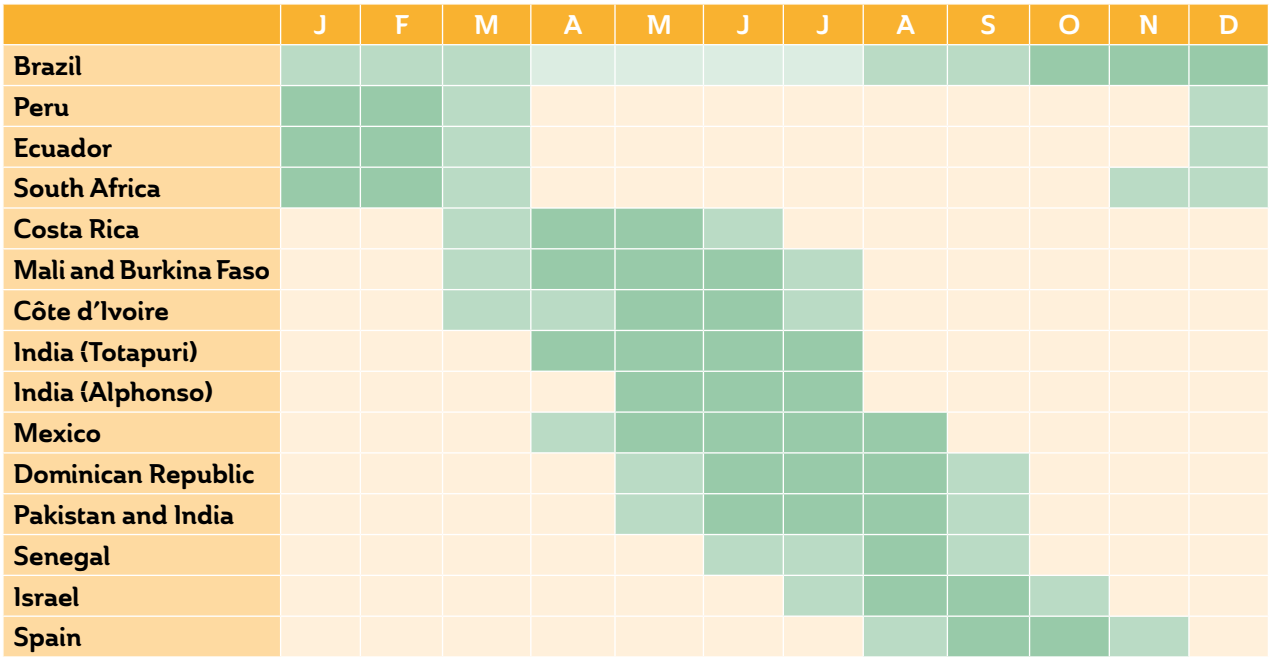

Figure 15. Overview of mango season in key countries

Purée production can comfortably be accommodated by countries that export fresh, frozen or dried mango. Mango purée is often made from second or third grade fruit, or fruit that is cheap to produce, such as Totapuri.

In most fruit sectors, first grade fruit is for export or premium local markets. Second grade fruit, which may show some skin blemishes and a little discoloration, is used for the local fresh market, fresh fruit salads, drying and freezing. Third grade fruit, which can be too large or small and unattractive, is now only used for processing. Finally, fruit that is too ripe for fresh cut salads, IQF or dried fruit can still be used for juice. Only severely infected (diseased) fruit cannot be used because the fruit is pulped whole and there is no time to cut out infected parts. Infected fruit normally affects the flavour.

Because purée is an internationally very competitive market that requires scale, a factory needs to have access to large volumes of cheap fruit. Consequently, some countries such as Senegal and Ghana cannot be competitive because the price of mango there is simply too high.

3.4 Technology, processes and techniques

Fruit purées are rich in sugar. This requires specialised equipment for preventing spoiling.

3.4.1 Stage 1: Reception, washing, sorting and ripening

At reception a visual inspection of the fruit is done. The fruit is then washed in a water bath that can be dosed with chlorine or other products. It is then sorted, and any infected, overripe or rotten fruit is removed. Usually, this fruit can be collected by the supplier and is not paid for (it is excluded from the producer's remuneration). Accepted fruit is then ripened – in crates in a hall or outside under a roof, or in specialised ripening rooms.

Some factories will sort and ripen before washing. However, for more even ripening and

lower ripening losses, all fruit should be washed first.

3.4.2 Stage 2: Pulping

This is where the mango is mechanically squashed to separate the pulp, peel and pip. At the start of this stage mango may be washed again. Whether or not it is rewashed, it is sorted

Figure 16. Typical purée processing stages

3.4.3 Stage 3: Homogenising and blending

The pulp is pushed to the next vessel, where a second pulping phase takes place to blend or homogenise the mango purée.

3.4.4 Stage 4: Holding and pasteurising

If the product is frozen, it is flash heated to 90°C in a pasteuriser, and then chilled to below 10°C. If the product is aseptically filled, the sterilisation process will happen in the aseptic line prior to filling. Product that is concentrated is put through an evaporator.

3.4.5 Stage 5: Aseptic filling or freezing

Referring to Berlin Packaging, aseptic filling is the process of filling commercially sterilized products into pre-sterilized containers. For aseptic filling, product is most often packed in septic bags, which are sealed and placed in 210-litre or 219-kg drums for transportation. Should the customer require such, smaller aseptic bulk bags in boxes are an option.

For freezing, the mango purée is packed into double-walled foil bags and frozen.

3.4.6 Technology

For processing mango purée, a line with various components is required. These are shown in Figure [illegible] most im[illegible]ensive [illegible] in this line is and ster[illegible].

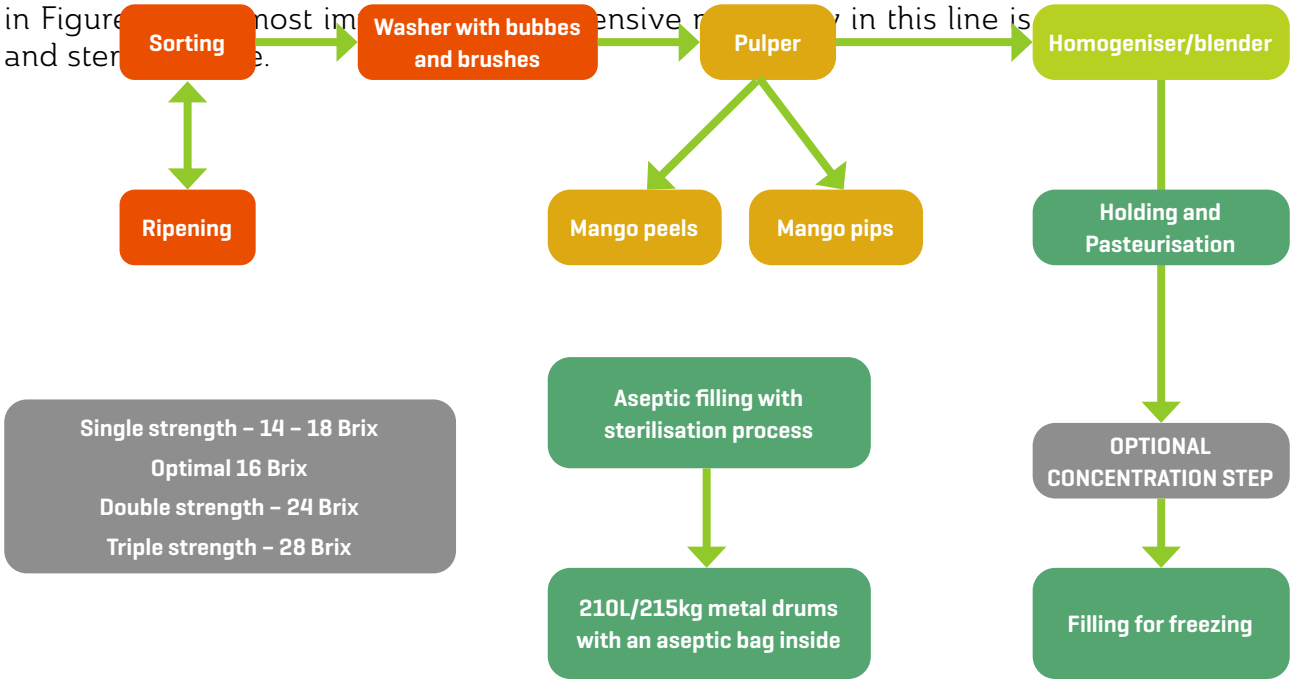

Figure 17. Purée processing with technology

- The smallest production line available is 5 tonnes of fresh mango per hour, though the actual capacity is between 4 and 5 tonnes. This depends on the speed at which the line is fed, which in turn depends on loading but also the speed of the sorting team behind the sorting belt. In addition, the pasteurisation and evaporation time needed influences the speed.
- Yields range between 55% and 65%, depending on the variety, size of mangoes, quality of mango and losses during the ripening process. For economic calculations, 58% should be taken for new factories and 60% for existing plants with qualified staff and good supply chain management.
- Production lines can be sourced from India and China, but the quality and availability of parts is not reliable, so the best option is to source from Italy, where there are at least two reputable suppliers.
- To set up a plant, a minimum of 1 hectare of land is required, which would need to be fenced. The buildings house the production line, an office, a small laboratory, ripening rooms, and final product storage.
- The production line needs an additional boiler for steam that is fed to the concentration and pasteurising units and a generator for backup electricity. These are normally sourced from separate suppliers.
- The approximate cost of setting up a processing line is detailed in Table 1.

Table 1. Approximate production line costs

Equipment	Number	Unit price (US$)	Cost (US$)	Month of purchase	Lifetime (years)
Juice processing line Bertuzzi	1	1,629,080	1,629,080	6	10
Generator	1	28,000	28,000	9	10
Boiler for steam	1	28,000	28,000	9	10
Lab equipment	1	28,000	28,000	9	10
Pallet jacks and small equipment	1	28,000	28,000	9	3
Plastic crates	55,000	6	302,500	12	3
Total			2,043,580		

When concentrating mango purée, flavour is lost through volatile oils. Installation of a flavour-recovery unit is a consideration to keep the standard of the purée high. Alternately, what evaporates can be sold as mango extract. The cost of a flavour-recovery unit would be between US$50,000 and US$100,000.

Usually, the cost of the land and building are 50% of the total investment cost, with equipment accounting for the other 50%. The total cost of a mango purée plant is around US$4 million. The production can normally be doubled or tripled by adding one or two lines in parallel. The building design and services (e.g. boiler) should be done in a way that extra lines can be added.

3.5 Ingredients for success

3.5.1 Make a choice between bottling or juice, but do not mix your drinks

The most common mistake in Africa is that entrepreneurs want to produce juices from fruit and bottle and sell them. However, these are two distinctly different business models that are separated in most of the world for a good reason. They both require large scale and large investments to be competitive.

Juice producers or plants purchase large amounts of fruit and produce an intermediate or industrial product that they usually export. They are focused on supply of fruit, processing and business-to-business marketing. They go to trade fairs to find clients. They need focus to reach scale, because the minimum size of a line is 5 tonnes of fresh fruit per hour. They need to produce about 10,000 tonnes of juice and concentrate per year to cover their fixed costs. They usually focus on two or three juices. As already noted (section 3.4.6), the minimum investment is around US$4 million.

Juice bottlers on the other hand never touch a piece of fresh fruit. They need to source juices and concentrates from around the world, and blend and package them on an industrial scale. They try to produce the most interesting juice for consumers at the lowest price, by blending perhaps five different juices into one flavour. They need to have the same flavours available year round. They are in essence a packaging, marketing and distribution company. They are focused on business-to-consumer marketing, which means they are involved in television, radio, billboard and internet advertising, product sampling, public relations, and

retailer incentives. The minimum investment is around US$5 million, because even one Tetra Pak filling line can cost US$2 million and fills 20 million litres per year. You need this scale to bring down the unit cost and be competitive with soft drinks.
Mixing the two models has a number of issues. First, the investment cost is extremely high. Second, when you use only your own concentrate or juice, the price can vary hugely each year. Also, your sales are now limited by the juice you can produce yourselves. Third, your attention is spread across too many professional areas, which introduces unnecessary risk to companies.

3.5.2 Certification: HACCP and others

Most buyers of purée will as a minimum expect HACCP certification. Additional certification will facilitate marketing of purée to new customers.

3.5.3 Multi-season production

Purée manufacture for export globally or in the region requires professional production. To afford the specialised equipment for production at industrial scale and to be able to invest in skilled staff, the factory needs to operate for much of the year. This is only possible by introducing a variety of products with complementary seasons.

First, fruits with longer productions seasons, such as pineapple, can be considered. Other local fruits such as orange can also be included. Global trends also provide some interesting ideas. The vegetable–fruit juice trend could be explored. Some vegetable purées in demand include carrot, cucumber, celery and beetroot. Purées are also in demand in food manufacturing of products such as baby foods, or for frozen or baked foods. These include pumpkin, sweet potato, potato, spinach, mushroom, green beans, courgette and peppers.

The trend of adding herbs and spices suggest even more novel opportunities: ginger and turmeric are examples.

3.5.4 Access to market: find a strategic partner

Processors looking to export product need to consider that the juice market is global and exceptionally competitive. You are most likely trying to convince an importer to replace someone else's product with your product. In the absence of a track record as a supplier of quality product, this is not easy. Why would they drop a well-performing supplier for someone who has not proven themself?

In other markets you can perhaps convince clients that you have a unique flavour, you can supply at a different time, etc. But juice has a long shelf life, and being different is not necessary an advantage, because it means the flavour of the final product will change. And if you supply something for a new product, the lead time will be long.

This all means that unless you start exporting in a year when the harvest has been bad in India and one or two other key supplying markets, you will struggle. You will need to give heavy discounts of at least US$100 per tonne to get into the market. Unless of course you have a relationship with an importer, who may have shares in your business or with whom you have signed a long-term sales agreement.

Another challenge a new producer will encounter is cash flow. If you still need to find clients when you start production, you will run out of cash very quickly. Each day in which you work

8 hours you will produce at least a container of juice, worth around €15,000, that probably costs you €10,000. After one month of processing without selling, you will have €300,000 locked up in stock, and will likely be running out of working capital and place to store stock. Furthermore, even if you sell that day, you are not likely to get paid an advance for another 30 days, while payment in full takes another 90 days at least. You will be forced to close down production until you have money, which means your earnings will not be sufficient to pay off the investment loans.

Thus, the best route is to develop strategic partnership with importers (one or more) with whom you can develop your business, and you have guaranteed sales volumes at the start of the season. This partnership would allow you to learn more about the end customer's requirements and to win a space in the global sourcing calendar. It could also help to inform innovation, certification decisions, etc., so that you have an increasingly marketable product.

A second option is to find an experienced distributor or agent and develop your own sales organisation in the end markets. This gives better connectivity to food ingredients companies and lowers the barriers to them sourcing from your company. It is important in this second option to appoint agents who understand the market, have good customer service and who are respected by their peers in the small juice world.

3.5.5 Sound financial planning

Before you start the business, you need to make a detailed cost–price calculations based on the local cost, international benchmarks of processing efficiency, etc. These then need to be compared to world market prices of similar products. Though this sounds logical, most African juice entrepreneurs have never done this kind of calculation. They thus risk building a factory that will never export because their product cannot compete on the international market.

Next, a realistic time frame and financial planning are needed. Construction of a plant will take at least 12 months, so if you are not starting before the mango season, you will not be operational the next season. Furthermore, the first season needs to be planned in as a test season, where limited volumes are produced as the staff learn how to source large volumes of fruit, and ripen and process the fruit. This will require patient capital.

Finally, sound cash flow planning based on realistic assumptions is essential. For example, the payment terms of clients plus one month. It is very common for plants in Africa to run out of cash, which means farmers are not paid. They then stop supplying, and the business eventually shuts down.

3.5.6 Sourcing excellence

A large professional factory needs sufficient volume throughput to make juice production economically viable. This hinges on being able to source enough fruit suitable for juicing. With growing competition in the region this could mean sourcing from neighbouring countries and/or sourcing product from dried mango processors and fresh mango exporters. This is not simple. But companies that can master local and potentially regional sourcing have a distinct advantage.

This could include having your own experienced sourcing managers, extension workers, harvesting teams, transport crates and trucks. The key question there is whether you need to own trucks, or you can rent trucks with drivers to reduce the investment cost.

A good sourcing strategy also includes an understanding of your role or importance to the

farmer. As a juice producer you normally cannot compete with export and premium fresh markets for fruit. You simply cannot afford to pay those prices. So, you need to develop an attractive proposition to farmers that is not price.

There are a number of creative options to develop a good proposition. It could be that you develop a juice grade, and you purchase only those fruits that others cannot use (second and/or third grade fruit). Or you pay an advance or cash on delivery, so farmers sell to you because you solve their cash flow problem. Perhaps you can offer to organise harvesting teams and transport, thereby making the life of the farmer easier. Or you could offer orchard maintenance services.

In any case, sourcing will require dedicated staff who build relationships with farmers and are on the ground throughout the year to estimate the coming crop, and during the season are focused on getting their hands on the mango.

3.5.7 Operational excellence

Good juicing factories rely on experienced factory managers and production staff to introduce and maintain quality, food safety and efficient operations. This allows the factory to respond to unexpected mechanical issues with equipment, carry out planned maintenance and ensure that the equipment is being maintained well.

This team should include skilled maintenance personnel in the company, but also access to suppliers who are able to source parts for repairs or new lines.

3.5.8 Good variety strategies

Most food ingredients companies and juice companies look to create a standard blend. This means that they need to be cautious about introducing new flavours to their product portfolio. This could be either new varieties, or even in accommodating large fluctuations in

flavour. Counterintuitively, introducing a new unfamiliar variety could be problematic. They need to ask whether this would be marketable to their clients. Is the flavour similar to an existing origin or variety? Could they market it to a buyer who is looking for a special edition flavour? Or would this just add complexity?

3.6 Issues and opportunities summary

Table 2. Issues and opportunities

Issues	Opportunities
▪ Declining juice market ▪ Highly competitive market with relatively few buyers ▪ Global sourcing ensures that smaller suppliers compete with large companies in major sourcing origins ▪ High cost of mangoes in Africa linked to smaller production and competition from fresh exporters and dried mango processors ▪ The market demands quality production that necessitates highly technical production – success hinges on operational excellence at each stage of production ▪ Economies of scale matter, but this requires sound economic planning, good sourcing and excellent operations ▪ Unfamiliar varieties struggle to get a space in the global sourcing calendar	▪ Processors with multi-season, multi-product systems are most likely to succeed – growth in vegetable purées might offer opportunities ▪ Increasingly innovative market, which could be open to new specifications with the right degree of preparatory work (e.g. demonstrating the flavour, Brix) ▪ Opportunities for differentiation – organic, product range (vegetable and fruit), seasons, sustainability, etc. ▪ Regional buyers source purées on the global market – could they offer a market nearby?

4 FROZEN MANGO (IQF)

This chapter has been developed by the Fit For Market + and Fit For Market SPS programmes, implemented by COLEAD within the framework of the Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union (EU).

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Contents

1. What is IQF mango?

The term individually quick-frozen (IQF) refers to the fact that the cubes are frozen in a way so they do not stick to each other and retain their original shape.

Because the freezing process is quick, small ice crystals form, which do not damage the tissue or cellular structure of the fruit. This means that on defrosting the fruit is firm and resembles fresh cut fruit.

Boxes of mango cubes are sold in supermarkets and via wholesalers and other stores that service restaurants.

Frozen mango comes in two main forms: frozen cubes used in the food industry and for smoothies, and longer chunks used for fresh fruit salads and baked goods. The standard size for cubes is 10 mm, but 15 mm and 20 mm are also used.

2. Demand

The demand for IQF fruits has been growing in most regions of the world. The total market is expected to grow to €5.9 billion by 2029. About 53% of the global frozen fruit volume globally is berries, while citrus and tropical fruits have a significantly smaller market share. Nevertheless, tropical fruits are growing in popularity in North America and Europe. As a result, frozen pineapple, mango, dragon fruit, papaya, banana, etc., can be found in more supermarkets and are being supplied by companies that supply hotels, restaurants, caterers, bakeries, etc. Mango is a particular favourite. One importer can easily buy 3,000 tonnes per year.

Frozen fruits are used in the home, industrially and in the hospitality industry. At home people use frozen mango to prepare smoothies, as toppings for breakfast yoghurts or for desserts. The hospitality industry (restaurants, hotels, catering, smoothie bars) uses frozen mango cubes and slices in fruit salads, on desserts and in smoothies. Home consumption and hospitality account for roughly one third of frozen fruit consumption, including mango. In this segment frozen mango competes with fresh fruit.

Two thirds of frozen mango globally is used in the food industry in baked goods, as pie filings, in toppings, in desserts, in baby foods and to flavour dairy products. It is in competition with mango purée and used to produce premium products that require some "fruity structure". The products might also need to have pieces of fruit in them. Often, frozen mango is preferred over purée or dried as it gives a more suitable texture and an appearance that cannot be delivered by pulp. Chunky yoghurts, smoothies, jams and ice creams are some examples of where frozen mango cubes are sometimes selected. Sometimes food manufacturers use frozen mango directly, but in many cases a supplier will use it to make a preparation where it is blanched, and other ingredients are added.

Figure 1. A range of products that use frozen mango as a key ingredient
Source: Authors from trade visits

Finally, the fresh cut salad market has an interesting interplay with the frozen cube market. The producers of these salads sometimes use frozen fruit as a substitute for fresh cut fruit. This has the distinct advantage of allowing them to source fruit all year round and to balance their ingredient prices. When fresh cut fruit is expensive, they can substitute it with frozen fruit and vice versa.

Berries make up the biggest share of IQF fruit traded around the world, because they have a short shelf life and are very seasonal. Most berries need to be consumed within a few days of harvesting, and they are very easily damaged. This requires careful handling, packaging, and refrigerated transport and storage. Having sufficient fresh berries for deserts, smoothies and salads is very difficult for restaurants. Furthermore, fresh berries are quite expensive and most restaurants cannot afford to throw away berries if there is a lack of demand. Finally, labour for production and fruit picking is one of the main cost factors in berry production, and the cost can be greatly reduced if berries are produced in, for example, Morocco or Mexico. Many of these characteristics are shared with tropical fruits. But frozen berries were perhaps more familiar in the premium markets where the technology was developed.

Frozen fruit offers great advantages for restaurants or food manufacturers. It is easier to prepare and cheaper than fresh fruit. Sourcing of fresh fruit is not needed, there is little waste from unused fruit, and it cuts out labour-intensive cutting of fresh fruit. Frozen mango cubes can be much cheaper to transport than fresh mango, as there is no wasted space in the container and no transport of skins and pips. In addition, second and third grade fruit unsuitable for fresh export can be used for frozen chunks.

2.1 Market size in Europe and the USA

By 2019, the European frozen tropical fruit market was €145 million, with steady growth (>7%). Some growth came directly from developing countries, while a good deal of growth came from EU countries[1]. The specific volumes of frozen mango cubes being traded in Europe are unknown. However, industry experts' estimates suggest that there could be as much as 20,000–25,000 tonnes of IQF mango being imported per year.

Mango contributes a large volume to frozen fruit imports. Demand for IQF mango is growing in the USA (see Figure 2).

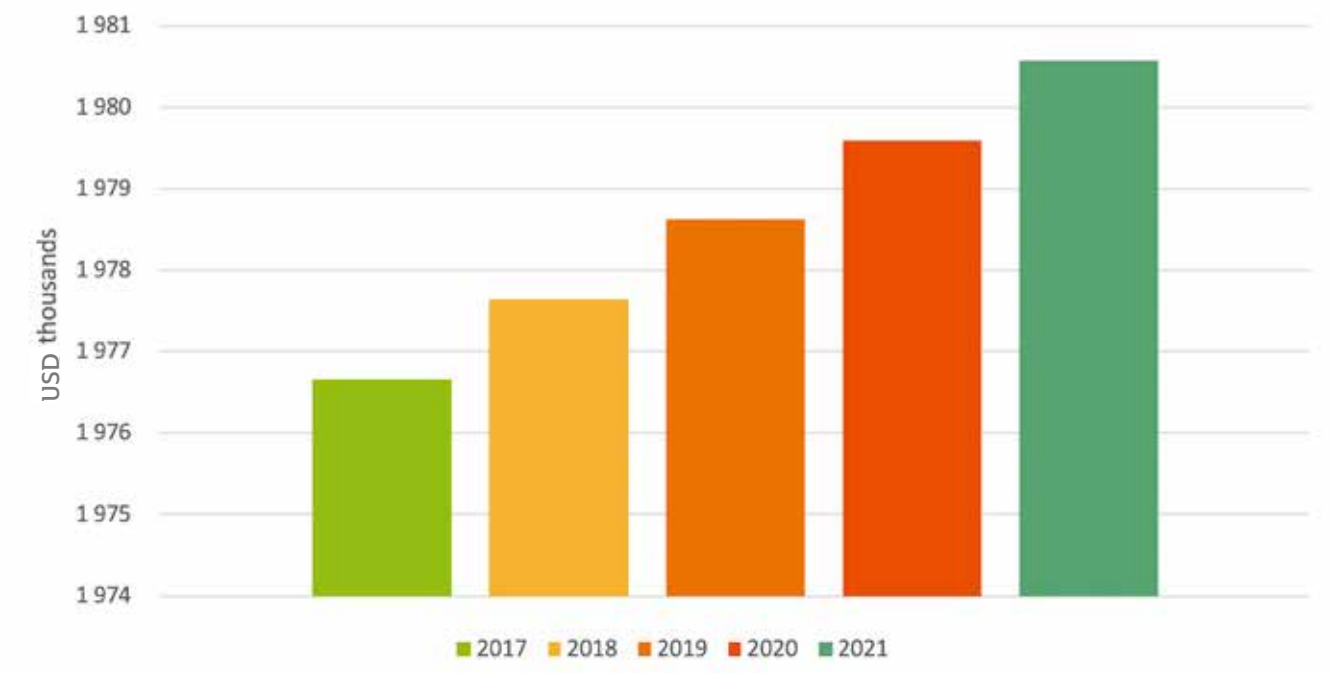


Figure 2. Value of IQF mango imports into the USA, 2017–2021 (USD thousands)

Given the growing demand and frequent shortage of supply, importers are very interested in finding new suppliers of mango. The product must meet their definition of the market standard, Kent. This specific variety is in great demand. Importers are willing to provide advice and invest time in working together to develop new producers. However, good samples are crucial to convince them, particularly for varieties other than Kent. The reason is that all their clients like Kent and they do not need to explain to them what kind of product it is; it is thus an easy sell. Nevertheless, they are willing to consider other varieties after some persuasion.

1 Autentika Global (2020) The European market potential for tropical frozen fruit. CBI. "http://www.cbi.eu/market-information/processed-fruit-vegetables-edible-nuts/tropical-frozen-fruit/market-potential"www.cbi.eu/market-information/processed-fruit-vegetables-edible-nuts/tropical-frozen-fruit/market-potential

2.2 Market trends

Smoothies

Figure 3. Smoothie market
Source: (left) www.alberts.be (right) www.unsplash.com

The smoothie market is thriving in both established and emerging markets. The increasing number of health-conscious clients, changing lifestyles and eating patterns, and the health advantages associated with smoothies are all important factors driving interest in enjoying smoothies. Customers are shifting away from high-carbohydrate meals, towards protein-rich alternatives and ingredients that are free of gluten.

People are also drinking more functional beverages, such as smoothies, to meet their daily nutritional needs. Furthermore, since people lead busier lifestyles and work longer hours, there is a greater desire for more convenient eating alternatives.

Smoothie bars and health restaurants have been innovating to bring new concepts to market. These include smoothie bowls, vegetable and fruit blends, adding herbs and spices, and offering home delivery of a week's or even a month's supply of smoothies.

This has inspired home preparation, which often relies on fresh and frozen products to add flavour and nutrition in smoothie recipes. The rapid growth of at-home preparation has perhaps prevented prepared bottled smoothies from truly taking off. Many food manufacturers have had to withdraw product from shelves as they have not been able to get people to regularly buy their packaged smoothies. This does not mean that smoothies are not a growing market. It means that getting a share of that market might require reaching shoppers through IQF, or via juice bars and other specialised health food outlets.

Confectionary and bakery

Mango has become so popular that it is becoming a regular ingredient in desserts, salads, breakfast bars, etc. Frozen mango cubes are available for most of the year and so give food outlets access to a desirable ingredient all year round. The tidy, pre-sliced format makes it convenient to use and reduces waste in the kitchen. It is an ideal format for restaurants, hotels and confectioners who are looking for ways to simplify their ingredient lists, reduce labour and better manage waste.

Figure 4. A mango dessert
Source: unsplash.com

Labour shortages

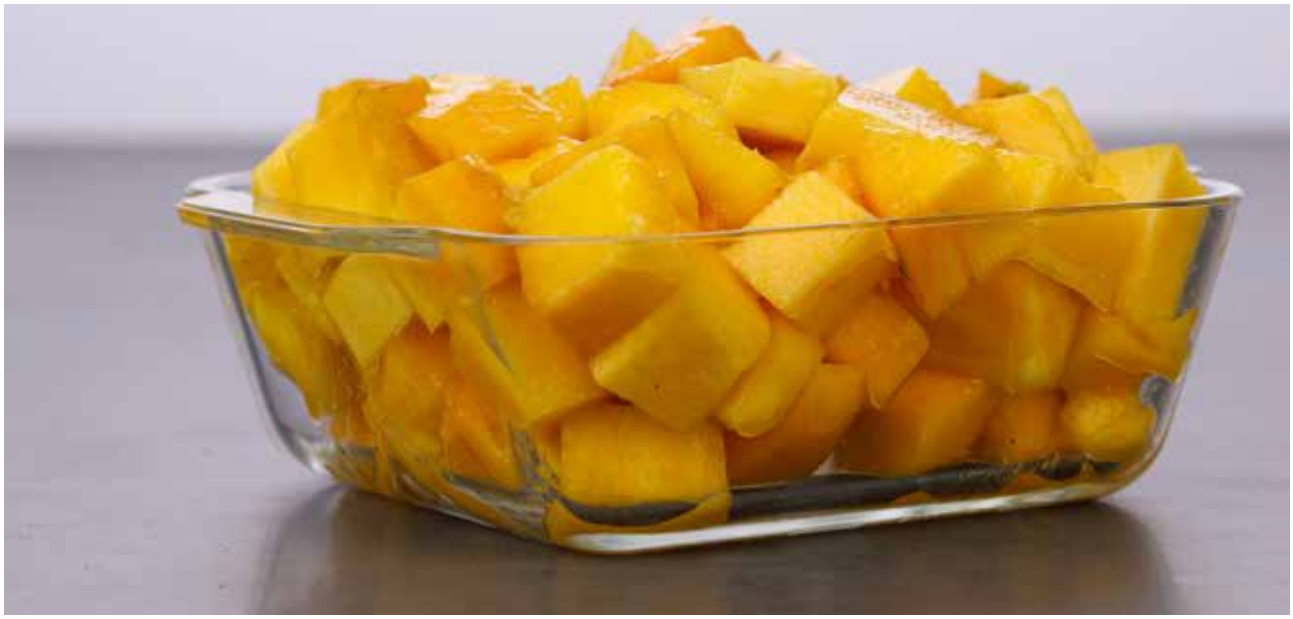
The COVID-19 pandemic has created significant shifts in the labour market. The hospitality sector has experienced difficulties, with labour shortages now common in all major economies. This creates far greater pressure on restaurants to manage more with fewer people. Using products that are prepared and do not need much handling is one strategy that could help in this. Frozen mango cubes can deliver these benefits, while helping companies to simplify management of the shelf life and seasonality of ingredients.

2.3 Certifications, quality standards, etc.

Each client has different specifications for their product, in terms of colour, sweetness, flavour, size and hardness of the cube. Nevertheless, most prefer a dark yellow–light orange colour with a typical ripe mango flavour, low fibre and a cube that is still soft enough to eat but hard enough that it keeps its shape and structure once it is defrosted. The required hardness also depends on how the product is processed: the more machines are used, the harder it needs to be. In terms of cuts, the two dominant preparations are hand-cut chunks (mainly used in fruit salads) and cubes (most 10 mm, though 15 mm and 20 mm are also sold). Certification (hazard analysis and critical control points [HACCP], etc.) is increasingly demanded by clients. The most important buying criteria are described in Table 1.

Table 1. Buying specifications for IQF mango

Maturity cut	Mangoes have matured sufficiently to be full fleshed, tender and well ripened. 11–14 °Brix. The target cut is 25 mm ± 5 mm, uniform cut.
Freezing technique organoleptic	Acceptable freezing variety and manufactured in accordance with good manufacturing practices.
Product specification	Tolerance of 30% by weight for pieces smaller than 20 mm or greater than 30 mm.
Colour, flavour and aroma	Typically dark yellow–light orange colour. Product possesses a good characteristic normal flavour, aroma and appearance of mangoes. Free from objectionable flavour and odours of any type.
Storage and handling shelf life	Transport and store at 0°F (–17.8°C) or colder. 24 months at 0°F or colder.



2.3.1 Varieties

Kent (extensively grown in Peru) seems to be the preferred variety because it corresponds best with most client specifications.

Prior to 2018, importers were mostly looking for Kent, because they were happy with the colour, flavour and structure, and it was basically the only variety they knew (apart from Ivory from China). Today there is more space for other varieties. Many new countries have entered the market and brought with them different varieties. Anything that resembles Kent will work, such as a Keitt, Hayden, Edwards or Palmer; for the industry that reworks mango cubes into preparations less premium varieties such as Totapuri are also acceptable.

Tommy Atkins is accepted by the market but has more fibre and is therefore not a premium product. Varieties Amélie, Lippens and Brooks grown in West Africa are unknown on the market, and it will take serious marketing efforts and some discounts to move importers to them – unless the product is organic, in which case it is much easier to sell.

2.3.2 Organic

The organic market for frozen tropical fruit is relatively small, but growing. Baby food in particular is shifting to organic. Supplying countries often see organic tropical fruits as too niche and no countries have carved out a space for themselves as true organic specialists. This opens an interesting opportunity to enter the market.

Organic frozen fruit is, however, a specialist product, with specific importers focussing on the product. Organic frozen mango fetches a 10–15% premium over conventional frozen mango. There is a clear demand for organic IQF mango and a shortage of supply, as with other processed mango products. Thus, it is worthwhile exploring, particularly since West Africa still has many organic producers, and organic product can always be sold as conventional in case demand is limited.

3. Supply

3.1 How do these products reach the market, what is the value chain structure?

The value chain for IQF fruit is very similar to that of fruit purées and concentrates. Producers in the tropics export to an importer or compound house/prep house. Many importers of frozen fruits also import purées and concentrates, but there are also companies that specialise in frozen products.

Some prep houses make fruit preparations for the food industry. Importers sell to prep houses, but also to wholesalers for the hospitality industry, to supermarkets, to food companies directly and on some occasions to fresh cut fruit salad producers.

In Europe, most importers are located in Belgium, the Netherlands, France and Germany. With companies such as ARDO, CROPS and DIRAFROST, Belgium plays a disproportionally large role in the frozen fruits and vegetables market and is a major exporter of frozen fruits to the rest of Europe. The Netherlands has a similar role, for example with importers such as Netra Agro and Rolin. However, vertical integration is also a trend in frozen fruit, with more products being sourced directly by food producers themselves in the tropics.

Importers are increasingly looking to reduce food safety risks, to secure volumes all year around and to encourage better product handling. These are essential in Europe and the USA where these are important terms of doing business with large manufacturers and retailers.

As a result, strategic partnerships down the value chain as well as mergers and acquisitions are more common than before. Many importers have strategic partnerships with producers or are investing in factories. Importers might themselves be involved in mergers or buyouts to get better efficiencies down the value chain. A key example is the ARDO–VLM merger, which gave the Belgian firm, ARDO, greater access to US markets as well as a controlling stake in Compania Frutera, Costa Rica's largest frozen pineapple manufacturer.

The largest challenge for importers and processors prior to the COVID-19 pandemic was the lack of reliability of suppliers when it came to fulfilling contracts. Importers close contracts ahead of the season with their clients, and on the supply side with factories and/or other traders. When the harvest is poor producers often do not have enough to sell, and what they do have they often sell to other traders who offer a higher price than those they have signed contracts with. They then make excuses as to why they cannot deliver, leaving the importer with the need to dishonour the contract or buy mango elsewhere on the spot market.

Strategic partnerships and increased vertical integration, which were emerging pre-pandemic, are often attempts to avoid these issues. In this model, the businesses in the value chain work together to build their joint business in the sector. Prices are a negotiation between the growers, processors and importers, and might at times be higher or lower than the spot market prices. Over the long term this shared value for the actors in the chain is beneficial as it reduces risk and uncertainty, and allows them to build the category and their reputation within the category together.

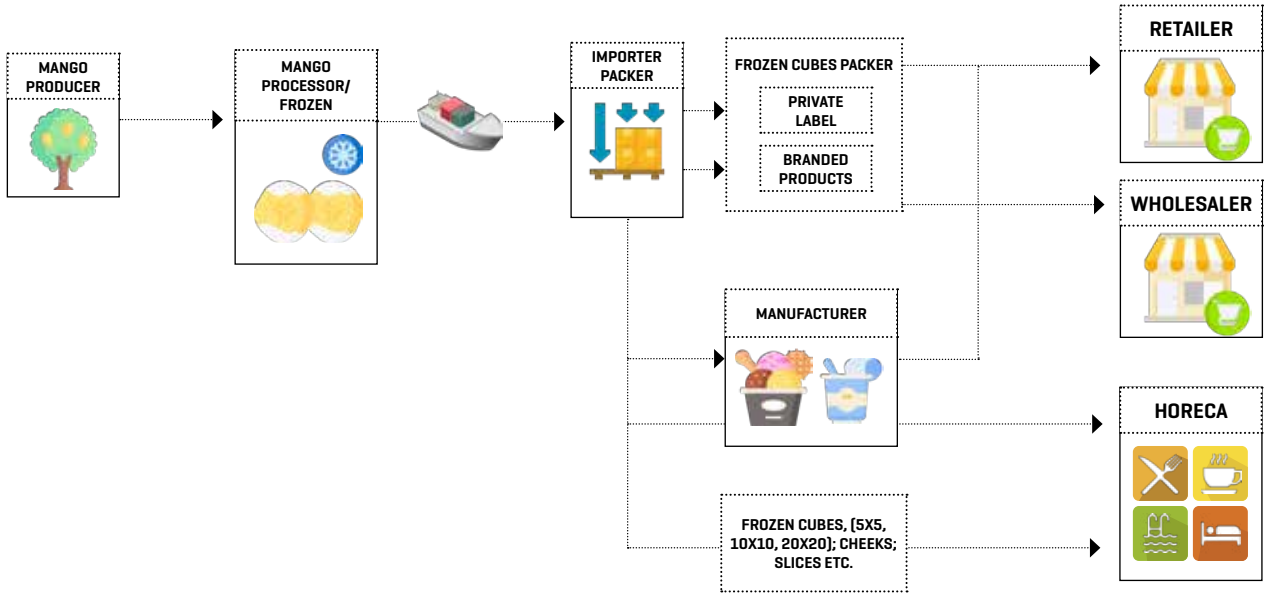


Figure 5. Market structure for frozen tropical fruit
Source: Authors' own illustration based on interviews and desk research.

3.2 Main suppliers of IQF mango

The three largest suppliers of IQF mango globally are currently India, Mexico and Peru. Historically, China was an important supplier of cheap frozen mango cubes for industrial use, while India did not produce IQF. However, since the mid-2010s the role of China has been taken over by India. Historically, importers have had food safety concerns that makes them more hesitant to import frozen mango from China. More recently being able to export Kent has meant that China has become more competitive again, but uses more of its product domestically.

Pre-COVID demand for frozen mango sparked interest in production. New factories were opened across the world in countries such as Guatemala, Chile, Vietnam, the Philippines and Madagascar. While still small, their contribution to global IQF mango has been growing rapidly (CBI). Guatemala, Vietnam and Chile together supplied €7 million worth of IQF mango cubes to the USA in 2021.

Table 2. Origin of IQF mango imported into the USA, 2021 (€ millions)

Mexico	Peru	Guatemala	Vietnam	Chile	Canada	Ecuador
72.2	47	4	1.5	1.5	1	0.77

There are some regional differences in where products are sourced. Frozen mango cube for the US market is almost entirely supplied by exports from Latin America. Mexico and Peru deliver 91% of all frozen mango to the USA. In contrast, the top two suppliers to Europe are Peru and India.

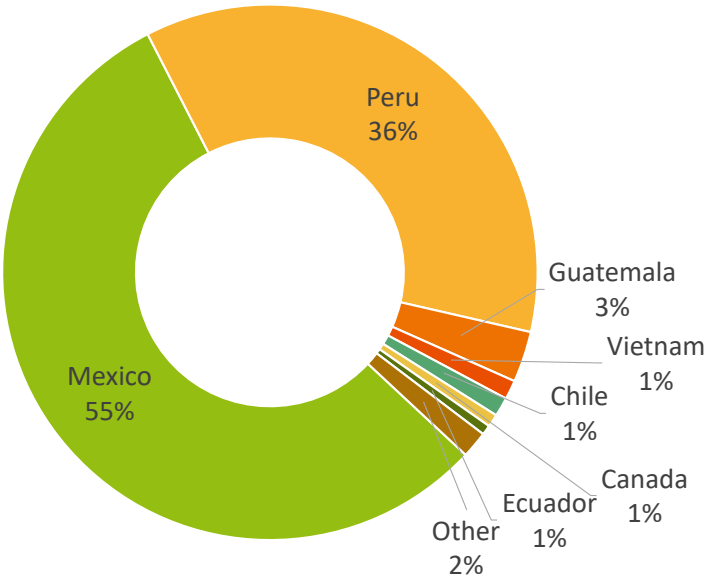


Figure 6. Contribution to US imports of frozen mango, 2021
Source: ITC Trade Map,

3.2.1 Producers – China

China is a large producer of IQF mango, but most production is used in the country itself. The dominant variety is Ivory. The product they produce is a very hard and light-coloured cube, which is not very popular on the international market, and only in demand by specific industrial processors. However, western companies try to avoid Chinese food products as much as they can because of concerns of chemical contamination and food adulteration.

3.2.2 Producers – India

India is a traditional producer of processed mango products such as pulp, but was not formerly a dominant player in IQF. They supply two products: Alphonso cubes and Totapuri cubes. Alphonso has an attractive orange–yellow colour with a sweet flavour. Totapuri is a lighter yellow with less flavour, but still relatively soft. Alphonso is very expensive and often in short supply. Because of its high price it is not imported in large quantities. Totapuri is much cheaper and imported in larger quantities, despite its shortcomings. Totapuri is only sold in machine-diced cubes for further processing into food products.

3.2.3 Producers – Peru

Peru is a relatively new player in mango processing, but they managed to obtain a dominant position in just a few years and have been the main supplier to Europe since about 2016. Despite growing competition, they are still dominating the market. The two main varieties from Peru are Kent, but Keitt, Edwards and Hayden are also used. Importers estimated in 2016 that there were about 10–15 factories in Peru, with an annual production of between twenty and sixty 40-foot containers (at 24 tonnes per container this means between 480 and 1,440 tonnes per year). Production has undoubtedly grown since then.

Figure 7. Frozen Peruvian mango in a German retail outlet
Source: authors from trade visits.

Factories do not seem to produce many other frozen products, which indicates that even with a four-month production season a factory can be profitable.

Hand-cut chunks of Kent and Keitt for fruit salads and other premium uses is an important market segment for Peruvian producers.

3.2.4 Producers – Mexico

Mexico also produces mainly Kent for frozen fruit cubes, but it is generally more expensive than Peruvian frozen mango cubes on the European market. Most Mexican produce goes to the nearby US market that can afford to pay more because the transport costs are lower. Europe only sources from Mexico if Peru cannot deliver the quantities it requires.

3.2.5 Producers – Thailand and others

Thailand is a traditional producer of IQF mango but seems to have stagnated in development and its position in the market has been lost to Peru. Ecuador is a new player, with Kent as the main variety. When supply of mango in Peru is short, Peruvian producers may source in Ecuador to fill their contracts. Some importers import directly from Ecuador. Vietnam is a new player, about which there is little information; it seems to lack the specific varieties that are currently in demand. There are also rumours of importers looking at Sierra Leone and Nigeria as possible suppliers.

3.3 Prices

The prices for IQF are considerably higher than for purée. Prices vary according to the variety and the supply volumes on the market at that moment. Totapuri from India and Ivory from China are the least desirable products and the cheapest (€1,840 per tonne for Totapuri, 2022). They are bought because of their low price. Alphonso is usually more expensive than Totapuri (as is its purée) and is currently available on the market for around €3,400 per tonne to Europe. In South Africa, Kent is available at €2,060 per tonne; however, retail prices in supermarkets equate to €8,350 per tonne, showing the huge margins.

The regular market price for Kent when there is a normal to good harvest in Peru, is around US$1,400 per tonne CIF Rotterdam; prices seldom drop much below this level. However, in a year of poor harvest in Peru, India or Mexico prices can increase rapidly to US$1,600 and even US$1,800 per tonne.

In such years, importers scramble to obtain enough mango to fulfil at least most of their existing contracts. This naturally drives the price up. Given the fact that in most producing countries the mango harvest is disappointing each second year, this is a situation that occurs frequently.

Table 3. IQF mango spot market prices in the USA by variety and origin

	Totapuri India	Alphonso India	Kent South Africa	Kent Peru	Ivory China
2018	€922	€2,000	–	€1,550	€920
2022	€1,840	€3,400	€2,060	€2,600	€3,750 *

* Mixed according to availability – 3 variants.

There is very little organic IQF on the market, and therefore we do not have a good overview of the price premium. Interviews suggest it is 10–15% as in the purée market.

3.4 Technology, processes and techniques

IQF mango is made by peeling the mango and removing the pip, which is usually done by hand. The large pieces are then cut by machine into cubes or cut into chunks by hand.[2] It may be blanched and cooled to preserve colour and juiciness. The mango is then put on a transport conveyor that moves through a freezer tunnel. The belt in the freezer has holes in the bottom through which frozen air is blown, moving the pieces while they freeze so that they do not freeze together in clumps. They are then packed in a plastic bag in 10 kg cardboard boxes (industry) or in smaller boxes for the consumer market.

3.4.1 Step 1: Reception and sorting of fruit

Fruit is received from the suppliers and weighed, and the quality is checked. Fruit is then sorted on ripeness and quality. Rejected mangoes are either returned to the client or used elsewhere – in any case, they are subtracted from the payment to the supplier. After sorting, the mango is stored in different cold stores. Depending on the maturity and supply needed in the factory, these stores can be switched on to delay the ripening process of a batch or left switched off. Water may be sprayed on the floor and ethylene gas used to accelerate ripening.

The equipment used at this stage consists of plastic crates for reception and sorting of mangoes, scales for weighing, and cooling rooms like those used by fresh fruit exporters (see Figure9).

Figure 8. Mango reception at a factory in Burkina Faso
Source: authors from factory visits.

2 Chunks are usually cut by hand or pressed by hand through a mould. It is also possible to use a running belt with knives on the end as used in mango drying plants.

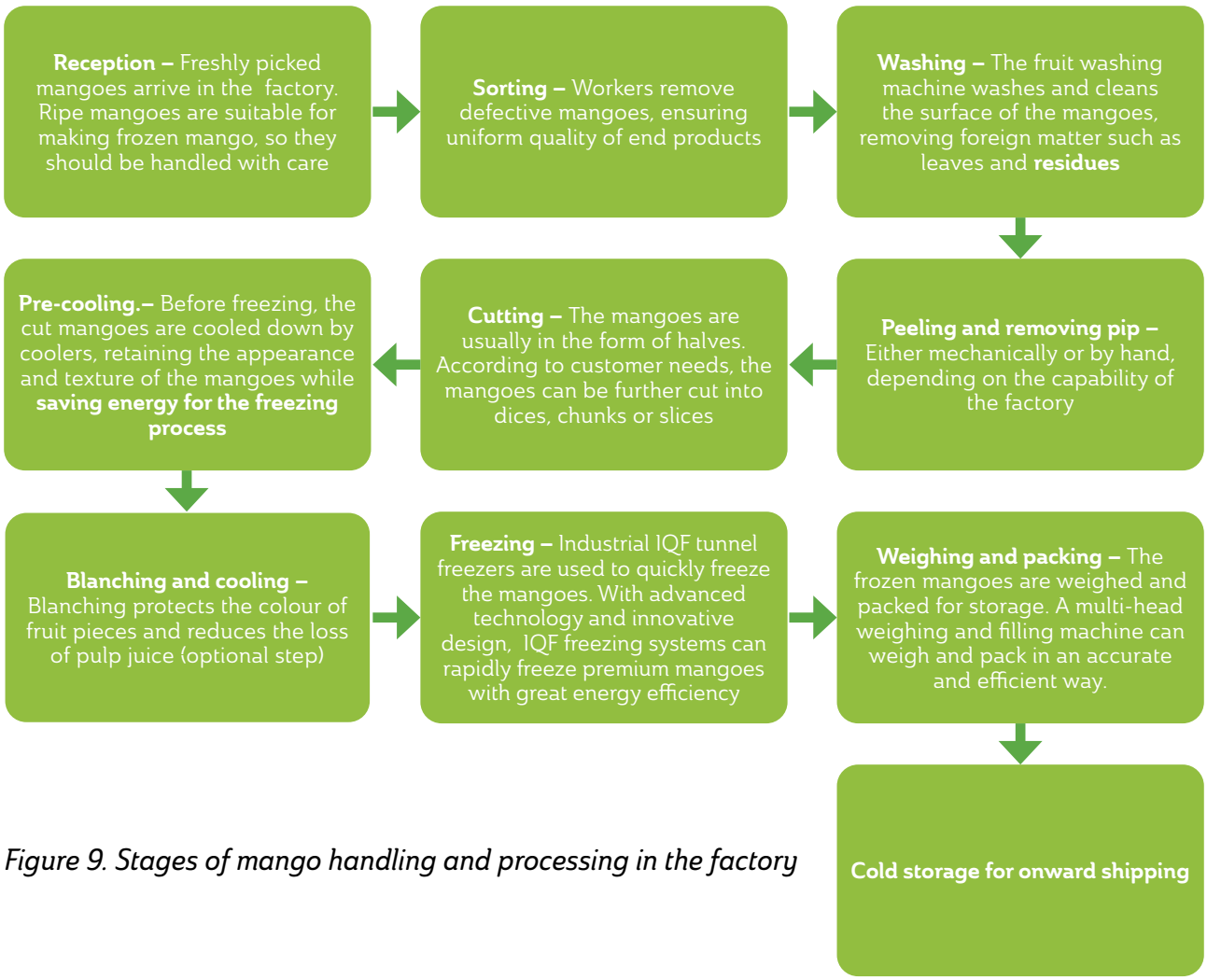


Figure 9. Stages of mango handling and processing in the factory

3.4.2 Step 2: Washing, disinfection and pre-cooling

Sufficiently ripened fruit is taken from the cold stores, weighed, and washed in a bath with a mild disinfectant to remove bacteria from the skin and thus reduce the risk of infection of the final product. The equipment used is a simple fruit washer similar to those used by fresh fruit mango exporters (see Figures 11 and 12). There are two types, those where mangoes float free in a bath and those where the crate is simply placed on a rail in the water and is transported by belt though the water. The advantage of the latter is reduced handling, as the crates can be lifted and supplied to the peelers working on simple tables.

We suggest at this stage you put a cooling element in the water, as the cold water will help to lower the temperature of the mangoes that at this stage may be 40°C if they do not come from a cold store. A reduced temperature also reduces the energy usage during the freezing stage and makes cubing easier.

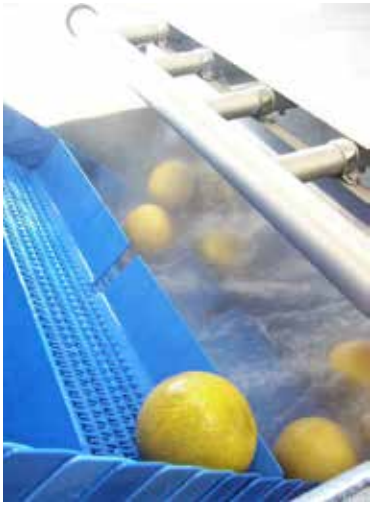


Figure 10. Mango fruit washer
Source: authors from factory visits.

Figure 11. Mango washing machine
Source: authors from factory visits.

3.4.3 Step 3: Peeling and slicing–destoning

The peeling and slicing–destoning of the mango can be done manually or by machine, depending on the factory. If by hand, dried mango factories of LVA in South Africa show that this is most efficiently done in groups of two. The first person peels off the skin with a potato peeler, while the second person cuts off the two cheeks and short sides and places these onto a conveyor belt.

Figure 12 Peeling and cutting of mango at an LVA factory
Source: authors from factory visits.

The only machinery used at this stage is a simple food-grade conveyor belt and elevator to transport the mango slices to the cubing machine and feed them into the top of it.

Equipment used here are stainless-steel peelers and knifes, and stainless-steel tables.

Most of the waste in the production process occurs at this stage – in the form of individual mangoes that are too ripe for processing after the ripening process, parts of mangoes that are too ripe and need to be removed, and the flesh of the mango that remains on the pip after cutting off the cheeks.

Experience of LVA in South Africa has shown that in a well-managed sorting, ripening and handling process, 65% of the weight of a fresh mango can be converted into slices, suitable in this case for dicing. The flesh stuck on the mango pip and (parts of) mangoes that are too ripe can be recovered and made into a pulp for juice or dried in the form of mango rolls. Generally, 10–15% of the fresh mango weight can be recovered into pulp.

3.4.4 Step 4: Cubing and sieving

Figure 13 Cubing and sieving mango in a factory
Source: authors from factory visits.

Cubing is a relatively simple process then can be carried out by one small but very efficient machine. The mango slices are fed into the top and cut by a series of knives into perfect 10 mm cubes that leave the machine at the bottom. The most used machine is the multi fruit dicer by the US firm Urschel. The cost of the machine is relatively modest (around US$35,000) and there is currently an Urschel dealer for North and West Africa. The same machine can be used to slice, dice and pulp a large variety of fruits and vegetables, by simply changing the cassette of knives. There are two basic mechanisms, one is slightly slower but treats the product more gently, which is needed to prevent brown marks on sliced apples. The other is faster but uses more force. It will be necessary to test these knife sets to decide which mechanism is optimal for mango, but tests with the latter gave little problems. By exchanging the knives, the size of the cubes can also be changed to 15 mm or 20 mm, and mango can even be pulped.

We initially assumed considerable loss at this stage in the form of juice. When you cut mango by hand you lose weight in the form of juice that leaks away because of the pressure applied with the hand and knife. However, during the machine test there was no juice or weight loss.

That said, tests do show a considerable loss in the form of half and quarter cubes and small end slivers after cubing. Because the mango cheeks have a round side, and the length, breadth and height of a piece is never precisely in whole centimetres there were always smaller parts after cubing. Clients tend to tolerate a maximum of 10% imperfect cubes, so a percentage needs to be sieved out. A simple screen sieve can be added after the cubing. We estimate a loss of 5–10% at this stage.

Figure 14. The Urschel Diversacut Sprint, suitable for cubing, slicing and pulping a large variety of fruits and vegetables
Source: Urschel.

3.4.5 Step 5: Precooling, dewatering and freezing

It is very important to cool the mango immediately after dicing. It is recommended that you use cooling water close to the freezing point, since the mango's temperature will slightly increase while it is transported on the conveyor belt to the freezer. If you want to obtain high-quality IQF mango, its temperature should be lower than 5°C (41°F) before entering the freezer.

This might seem like an additional effort but is necessary for a good freezing result.

Figure 15. Mango packaging
Source: www.saluzzocr.com

Efficient dewatering: it is important to make sure the mango is properly dewatered after cooling if you want to obtain a superior IQF mango. The maximum surface water should not exceed 2%.

The mango is now entering the freezer. Experienced IQF mango processors consider the optimal choice for the freezer infeed to be vibrating conveyors. The positioning of the infeed conveyor is of crucial importance as too high a drop can damage the surface of the product. And the feeding must be done at a constant rate.
Because of its complex technology, the fluid bed freezer is one of the most expensive machines in the process. Technology has progressed a lot, however, and we obtained quotes from both China and one of the original producers of IQF lines, Octofrost. China prices for a capacity of 3 t/hour upwards range from €223,110 and Octofrost costs around €450,000.

A refrigeration plant is required as the cold store for fresh mango. The refrigeration plant is an expensive part of the factory in terms of investment cost. A diesel generator supplies the energy of the refrigeration plant; this is a simple and inexpensive part of the factory, as second-hand, refurbished generators are readily available.

3.4.6 Step 6: Packaging

IQF mango is normally packaged in cardboard boxes in batches of 10 to 20 kg. After freezing, the cubes are transported by conveyor belt and fall into the boxes. A simple packaging machine is needed that divides the flow of cubes into pockets of 10 or 20 kg and then fills each box. The boxes are normally transported completely flat and will need to be folded; it is easiest and probably cheapest to do this manually.

It is important to obtain quality boxes, otherwise they
may collapse during transport and the final product will be damaged and rejected upon arrival. Most likely the boxes will need to be imported from Europe, Asia or South Africa.

3.4.7 Step 7: Storage and transport

Ample storage space is necessary, as transport to final clients may not be available regularly and some clients do not want to receive the full order at once. Because the cooling runs on diesel, there is no risk of loss of stock because of frequent power outages. Nevertheless, it will be important to negotiate rapid shipments with clients because storage under the high West African temperature using the expensive local fuel is more expensive than storage in

Europe.

3.5 Technology and total investment cost

Table 4 gives an overview of the investment cost of the plant and its energy usage.

Table 4. Investments in building and machinery for a 1-tonne/hour IQF production plant and energy requirements

Item	Estimated cost, Europe	Quoted cost, China	Power required (Europe/China)
Production hall of 500 m2, cold storage, office, and toilet/ changing room	€400,000	€400,000	
Multi fruit washer, capacity c. 3 t/hour	€30,000	€14,200	6.0 kW / 2.2 kW
6 Stainless steel tables for 38 cutters and peelers, plus conveyor belt for transport to cutters	€15,000	€12,000	1.5 kW / 0.75 kW
Mango dicer, capacity 2–3 t/hour, comprising 3 groups of adjustable knives	€35,000	€14,700	1.1 kW/ 2.2 kW
Freezer, capacity 3 t/h (start-up capital and on-site training)	€450,000	€223,110	Chinese line: ▪ 220 V/50 Hz single phase; 11.2 kW ▪ 380 V/50 Hz three phase; 62 kW
2 Screw elevators, including collection hoppers and adjustable-speed gear drives	€15,000	€12,300	4 kW / 1 kW
Separation vibrator for rejection of slivers	€13,500	€3,900	1 kW / 0.5 kW
Plant service, comprising water treatment plant, control panel, air compressor, set-up sundry items	€27,000	€27,000	5,0 kW
Automatic 20 kg packaging machine, manual tools for box sealing and labelling	€35,000	€39,500	1,0 kW / 1 kW
Refrigerated container storage	€15,000	€15,000	
Two diesel-electric generator sets, 350 kVA (new from South Africa)	€60,000	€60,000	
Ammonia refrigeration plant	€300,000		10 kW
2 x 40 ft Freezer rooms and 4 x 20 ft fridge rooms		€38,000	8 kW
Spare parts	€40,000	€30,000	
Shipping cost from	€34,000	€30,000	
Cost of erection, commissioning of equipment on site	€30,000	€30,000	
Total	**€1,499,500**	**€1,029,710**	
Various cost and unexpected 10%	€149,950	€102,971	
Total estimated cost	**€1,649,450**	**€1,132,681**	
Total power installed			334.6 kW / 110.8 KW

Source: Various independent suppliers.

The most uncertainty exists around the quote for the refrigeration plant, which seemed greatly inflated by an opportunistic supplier; the figure given in Table 4 has been revised downwards. The same can be said from the quote for the fruit washer, which has also been revised downwards. A quotation was obtained for a pre-cooling tunnel, but according to various experts this will not be needed.

The total estimated investment costs are around €1.15 million for a line from China, commissioned and with training provided. A line from Europe would cost approximately €1.65 million.

A smaller-scale machine from China with an input of 500 kg per hour and output of 300 kg per hour would cost €168,415 for the same set-up as in Table 4.

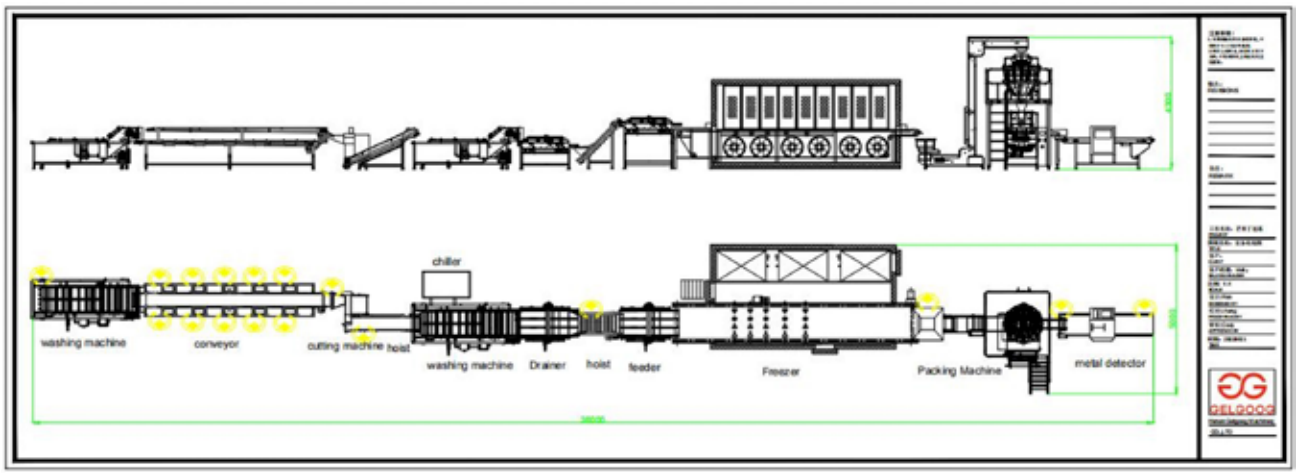


Figure 16. Gelgoog's technical drawing of the IQF processing line
Source: Gelgoog machine suppliers image.

3.6 Energy usage and power supply of the factory

The total energy usage of the factory for the line from China is estimated at 110.8 kW, compared to the line from Europe requiring 334.6 kW. This excludes the cold storage for ripening mango and finished product. The majority of this energy is used by the freezer fluid. If we include cold storage, which may not always be running, it is safe to assume a maximum of about 250 kW will be needed at peak production time (for the Chinese line).

One of the most critical parts of the production is the supply of the energy. In principle it is cheaper to run most equipment on locally provided electricity than on electricity generated by a diesel generator. However, the electricity needed for the refrigeration plant may exceed what can be supplied locally. Power outages of several hours up to half a day are frequent in Burkina Faso, and this would lead to unacceptable losses. Mangoes in cold chambers would ripen too soon, leading to riper mango than can be processed and thus a loss of product, valuable production time would be lost, and finely finished product would be lost because it would defrost. Therefore we allowed for the refrigeration plant run on its own diesel generator that has sufficient power to also supply the rest of the machines in the factory if needed. Furthermore, a backup generator is needed to allow for maintenance and service of the main generator.

Figure 17. Production of IQF samples: cutting and weighing of the cheeks (top left), cubing by machine (bottom left), collection of freshly diced cubes (bottom right) and freezing of the cubes (top right) Source: authors from factory visits.

3.7 Ingredients for success

3.7.1 Investment capital

Setting up IQF is both complicated and costly. The equipment is large, specialised plumbing is required, and creating and managing separate HACCP plans for each IQF product requires significant staff support. More importantly, to ensure the costly IQF system is utilised efficiently may require additional equipment or reconfiguration of production processes and storage space.

3.7.2 Technical control

One of the most difficult challenges processors face in IQF freezing is keeping the individual cubes separated. They can become quite sticky after being diced or sliced. The stickiness of processed product is the primary cause of lumps and blocks in the final product.

Another challenging issue for is retaining the flavour, aroma and texture of the goods while minimising dehydration of the product. This is essential for managing profitability. A natural looking and tasting product can fetch higher prices on the market. Excess dehydration negatively affects the final appearance, aroma, texture and taste.

The degree of dehydration also affects how much liquid is lost in processing. All of the moisture lost during the IQF freezing process translates into a decrease in product weight, which results in financial losses for IQF processors. This can be prevented by a blanching step, which locks in the juices and colour.

3.7.3 Location

The plant must be located where key raw materials, electric power, water, skilled labour and modern communication facilities are reliably available.

Although the general rule is to process close to your raw material source, in the case of IQF, it is preferable to be located close to the shipping location. With backup generators, you have control of storage facilities of raw and finished product. It makes better business sense to process at the shipping port, which eliminates the possibility of a break in cold chain during transport of finished goods. You can confidently deliver consistent quality at the point of onward shipping.

3.7.4 Range of products

In the long run, it is difficult for an IQF plant to be competitive by producing only during one season of typically 4 months per year. To remain competitive, processors need to look for opportunities to diversify out of mango.

Tropical fruits (passion fruit and pineapple) as well as vegetables are all possibilities that could be considered.

3.7.5 Reliable equipment, spares and repairs

Equipment should be reliable, made of food-grade material and suitable for the hot climate in Africa. The equipment should be robust enough to survive rough handling by unskilled staff and not too technologically complex.

It is especially important that servicing and maintenance are simple and easy to carry out. Ideally, spares would be easy to source and should be standard items available from various technology suppliers. Furthermore, it should be possible to use the essential pieces of equipment to produce other frozen fruits and vegetables. Any business that can use the equipment for only one product and only for a few months in the year will struggle to remain competitive in the long run.

3.7.6 Cold chain

Maintenance of cold chain at –20°C is essential till the product is delivered to the consumer.

The existing infrastructure used for refrigerated transport of fresh produce can also be used for transport of frozen produce. Surprisingly, transport of frozen produce should be cheaper and easier than that of fresh produce because a frozen state is easier to maintain than a temperature of 10–12° used for fresh mango. For fresh produce the cooling unit attached to the container needs to run continuously, as opposed to a frozen product where it only needs to run for a while if the temperature starts to exceed a threshold of –17°C.

Processors that supply fresh cut salad mangoes must be experts at local sourcing and logistics, to ensure that cold chain is well managed.

3.7.7 Utilisation of waste

Fruit processing plants always have waste or by-products, and few can afford not to process and sell this. Mango waste products that can be processed into valuable products are:

1. The flesh of the mango that remains on the pip after cutting off the cheeks
2. (Parts of) mangoes that are too ripe for processing into cubes
3. The small slivers sieved out after cubing.

We estimate that to arrive at 1 kg of cubes we need 2 kg of fresh mango. From the 1 kg of waste, 20% is usable as mango pulp. Table 5 provides the calculations of usable product per stage.

Table 5. Estimates of yields and waste during IQF mango production

		Percent-age	Weight (kg)
Fresh mango			**2.0**
Peeling and cutting of fresh mango	Slices	55%	1.1
	Pulp	15%	0.3
	Waste	30%	0.6
Cubing and saving of slices	Slices		1.1
	Cubes	90%	1.0
	Pulp	10%	0.1
Totals	Cubes	50%	1.0
	Waste	30%	0.6
	Pulp	20%	0.4

During the selection of mangoes, cutting and peeling, 55% of the mango is turned into cheeks and slices that can be diced; 30% is waste in the form of peels and pips and mango that is too ripe or diseased, and 15% is mango flesh that can be pulped. In dicing the slices, 10–20% of the total weight may be slivers and half or quarter cubes. Given a tolerance of

10% for imperfect cubes, we can safely assume that if we take out at least 10% of these by weight, the final product will be acceptable to the client. All of this can be turned into pulp, and added to the pulp obtained in the first step.

Assuming a total production of 1,664 tonnes of IQF mango, for which we need 3,328 tonnes of fresh mango, we end up with 665.6 tonnes of pulp.

There are three possible products that can be made with the mango pulp:

1. Mango juice for the local market, by adding sugar and water, and bottling
2. Mango pulp for export
3. Dried mango rolls for export or local market.

3.8 Issues and opportunities summary

Table 6. Issues and opportunities

Issues	Opportunities
▪ Expensive technology ▪ Challenging to manage cold chain ▪ Operationally demanding	▪ The processing technology preserves colour, texture and flavour ▪ Food trends and challenges with labour in the hospitality sector are positive trends for IQF ▪ Opportunities to use waste

5 | MANGO PICKLE

This chapter has been developed by the Fit For Market + and Fit For Market SPS programmes, implemented by COLEAD within the framework of the Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union (EU).

This chapter has been produced with the financial support of the EU and the OACPS. Its contents are the sole responsibility of COLEAD and can under no circumstances be regarded as reflecting the position of the EU or the OACPS. (more information).

Contents

1. What is mango pickle/achar?

Mango pickle is a traditional Indian condiment. It is prepared with fresh mangoes, spices and typically oil, and is enjoyed as a side dish. As Indians have migrated, so too has their cuisine. As a result, mango pickle can be enjoyed in many countries, but notably in those countries with big Indian populations.

Each mango pickle supplier uses a similar process but tweaks the recipe and ingredients to achieve a slightly difference product. It can be made with different fruits and vegetables, can be seasoned using a variety of spices, or even made with different types of oils. Some brands are experimenting with olive oil, for both mango and other pickles.

Figure 1. Different types of mango pickle available on the global market

Different intensities

With and without garlic, ginger and other spices

Without oil, or with alternate types of oil

Chunky

With other vegetables

Source: images sourced from brands' own websites and online retail stores.

Mango pickle is typically sold in glass or plastic jars. Plastic is more common in the developing world, especially in home industry production. Large catering packs are also available ranging from 1 kg to packs of several kilograms. These can be glass jars or plastic buckets.

1.1 Quality and standards specifications

The mango pickle market is spilt into two distinct parts – a formal market and an informal home industries segment. The formal market caters to local supermarkets and for export. Home industries supply product directly to shoppers or to small informal markets. As a result of this split there are two different quality standards.

First, for products destined for supermarkets or export, companies are investing in building brands and have a higher standard to meet. This is due to the demands of supermarket buyers and those customers in Europe and the USA who themselves are subject to higher food safety standards. Policing of these standards is also more likely in the formal market. Therefore, mango pickle producers producing for the formal market tend be hazard analysis and critical control point (HACCP) and British Retail Consortium (BRC) certified. This is certainly required for export.

Mango pickle sold in less formal markets in Africa tends to be unregulated. Shoppers then rely on the processor to have made a pickle that is both delicious and safe to eat.

1.2 Recipe

Recipes play an important part in pickle production.

Home cooks have leeway to produce recipes that are not consistent. Indeed, it is expected that they will leave their personal stamp on each batch. However, this is not the case in the formal market. Factories develop standard recipes, then work towards achieving a similar flavour and texture from season to season. This requires skilled product developers as there many variations in the intensity of the spiciness of the chillis from season to season, and flavour and texture differences also occur with mangoes.

1.3 Shelf life

Pickle is fundamentally a preservation method. So the recipes need to extend the shelf life. The selection of mangoes is important. Immature mangoes provide the right acidity. Then the mangoes are steeped in salt, before finally being bottled in oil. Such recipes all preserve product and ensure that mango pickle has an expected shelf life of 18–24 months.

1.4 Food safety

The processing, packaging and storage should be under strict food safety rules. Export of mango pickles requires at least HACCP certification. There is, however, no certification requirement in most African countries.

Packaging plays an important role in food safety. Some home industry producers might use jam jars that have been cleaned and readied for use in pickling. However, most larger factories purchase new glass or plastic containers. It is important when sourcing packaging that you look for a pack that can preserve the aroma of the spices, guard against light, moisture and air (which cause the oil to go rancid faster), has a good seal to prevent air entering, and should be grease, oil and acid resistant.

1.5 Softness

An enjoyable mango pickle has a soft texture. This means that the mango must be picked at about two to three weeks after fruiting so the fruit is still immature and the pip is soft (before the seed shell hardens). This is crucial. But it also means that the production season for mango pickle is usually very short. Home industry suppliers tend to supply product only during the season.

Larger suppliers can store and produce pickle year-round. The shelf life allows them to store enough product to last the year.

1.6 Variety

Though more than a thousand mango varieties exist, not all are suitable for making mango pickle.

In India, Rumani (apple mango) variety is recommended for mango pickle. In South Africa, home industry producers tend to use local varieties. Conversely, the larger producers prefer to source Tommy Atkins or Sensation. Pickling varieties should be acidic, fibrous and firm.

2. Demand

2.1 End market

Mango pickle as a category is still too small to track. However, we can learn something by looking at the distribution of the product. Mango pickle seems to have greater success in markets where there is a large Indian diaspora. The USA, South Africa, the UAE, Australia and the UK all have distribution in major national retailers, in small ethnic food shops and in webstores.

Newer markets are also developing. This is largely from a few large brands that supply and distribute product via distributors and their own teams around the world. In Africa, South Africa is arguably the largest market for pickles, followed by Kenya.

In countries where mango pickle is well established, there are opportunities to supply product to the food services sector – hotels, restaurants and caterers.

Figure 2. Mango pickle in bulk packaging (1l)
Source: Brand's own website.

2.2 Market trends

2.2.1 Healthier oils

This is an ideal format for Middle Eastern cuisine and for health-conscious shoppers looking to control their oil intake. As a result, processors have introduced oil-free mango pickle.

At the other end of the spectrum, processors are also introducing olive oil as a replacement for cheap seed oils such as sunflower oil, rapeseed oil and cotton seed oil. Olive oil allows mango pickle companies to claim health benefits such as being a therapeutic product, or that consumers can eat it without guilt.

Figure 3. Healthy oils
Source: www.unsplash.com

2.2.2 Increasing cost of oils

Oil is an important ingredient in mango pickle recipes. The growing cost of seed oils, especially sunflower oil, will undoubtedly put pressure on processors – in both the formal and informal markets. Price increases are thus very likely.

2.2.3 Garlic free

Garlic is a common ingredient added to pickles for flavour. However, Ayurvedic ways of eating discourage garlic in foods. Garlic free also allows processors to reach customers who simply do not like the flavour. Garlic-free mango pickle is thus being retailed in larger markets as a novel flavour.

Figure 4. Garlic
Source: Shutterstock

3. Supply

3.1 How does the product reach the end market, what is the value chain structure?

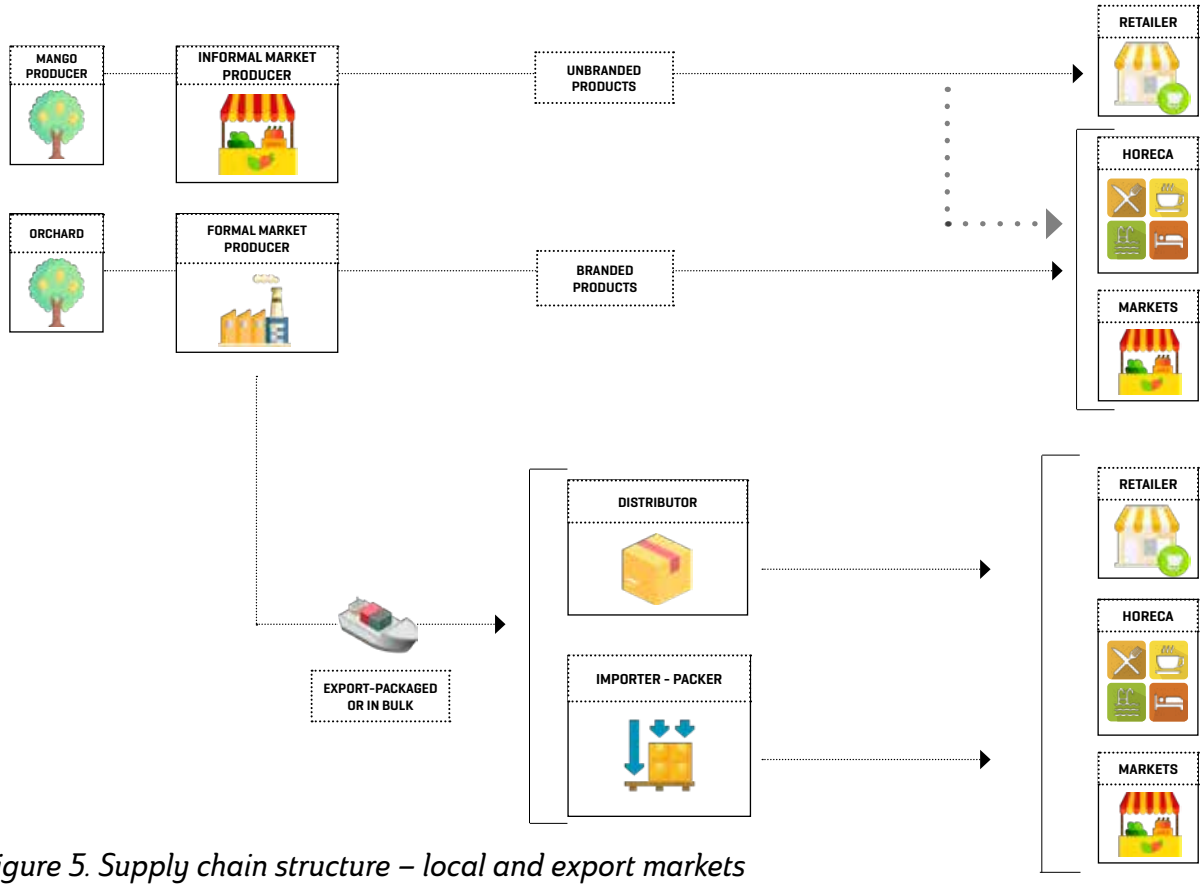


Figure 5. Supply chain structure – local and export markets

India is the largest supplier of mango pickle globally. It is no surprise then that there are several examples of Indian companies that have managed to distribute mango pickle in Europe, the USA, the UAE and other countries. Brands such as Ashoka, Telegu and Priya's Foods have distribution in large retailers such as Walmart in the USA, Tesco in the UK and Carrefour in the UAE.

A few brands traded globally are Patak's, a UK brand from AB World Foods, Ashok's & Telegu from India (trade under the company name) and Mother's Recipe Foods from Indian Continental Marketing. These brands have local distribution arms that enable distribution in key retailers. They also supply product via their own webstores and online shopping stores such as Amazon.

Growing interest in exotic foods has created interest in investing in exotic foods brands. AB Foods, a UK-based company, has invested in Patak's, an Indian food ingredients company. This is one of the largest suppliers of Indian flavours, sauces and pickles in western markets. Mango pickles are just some of their products.

While many of these companies produce and export under their own names, in at least one case there is a question of whether they ship product from India in bulk and then repack in Europe. This would assist significantly in managing shipping costs.

Typically, these larger brands compete against home-industry-scale producers, some who are building some degree of recognisability.

3.2 Seasonality, variety and availability

Mango pickle has a long shelf life, but the window for sourcing mango is very short. It also means that mango pickle production has a distinct peak when the trees fruit. Later in the year only those companies that can store product are able to supply outside of the peak season.

Many of the same varieties that are in demand for mango pickle are also in demand for dried mango, fresh mango cut into slices, mango juice and other mango products. With these options, farmers and people who own mango trees could get more attractive prices for fresh mango. Sourcing immature mangoes for mango pickle is thus challenging.

Local varieties might be suited to pickle production. Home cooks certainly do use immature local mangoes to produce pickle. However, more needs to be done to evaluate whether this can be done commercially – by sourcing mangoes and then testing them in commercial production. Not enough is known at this point to draw any conclusions.

3.3 Technology, processes and techniques

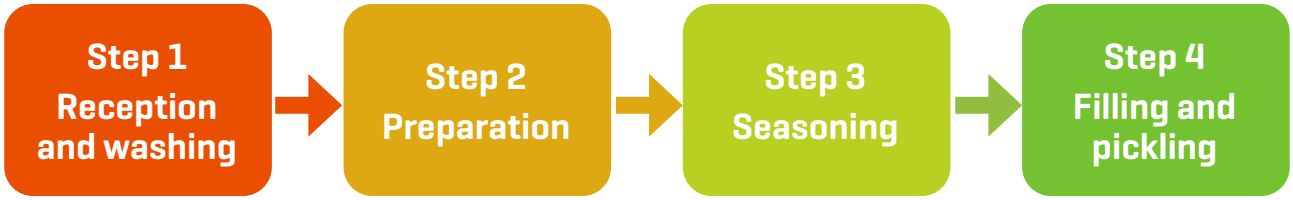


Figure 6. Process for producing mango pickle

3.3.1 Step 1: Reception and washing

Young mangoes are brought directly from the orchards. At the factory gate (or in the kitchen for home industries), they are sorted to ensure that they are young, fresh and do not have noticeable blemishes. Those mangoes that seem older than 3 weeks old are discarded.

The mangoes are then washed with clean water to remove sap, dust and dirt that might have adhered to them during picking. The washing is critical for food-safe mango pickle, and to ensure that the product has adequate shelf life. So, the mangoes tend to be washed at least three times. Mangoes are air-dried after being washed and the stalks are removed.

3.3.2 Step 2: Preparation (peeling, slicing)

In this step, preparation, the young mangoes are sliced or cut into chunks. They are usually left unpeeled and are not grated; however, occasionally the processor might opt to peel and/or grate them.

3.3.3 Step 3: Seasoning

In step 3, seasoning, the cut mangoes are mixed with salt or brine and cured. This may be anywhere from 1 hour to half a day depending on whether a dry or wet pickle is being prepared. The mango is then removed from the brine.

Finally, spices and oil are added to coat the mango pieces. Typically, these account for 5–10% of the recipe; however, the exact measurements depend on the recipe being used. Recipes can be quite different; common ingredients include ginger, garlic, chillis, fenugreek, asafoetida, cumin, turmeric and mustard seeds.

Oil is not used in a dry pickle. A preservative must be used in dry pickles, as oil plays an important role in giving flavour, colour and texture to wet pickle as well as in preservation of the product. Wet, oil-based pickles tend to have longer shelf life and can be stored unrefrigerated. Dry pickles need far more careful handling, preferably refrigeration.

3.3.4 Step 4: Filling and pickling

In this step, bottles, plastic jars, buckets or bulk containers for export can be filled with the seasoned mangoes. Filling can be done by hand or using automated equipment depending on the scale of production. Packages are then sealed, labelled and readied for shipment.

It is important to note that the filling process relies on using containers that are extremely clean. Any contamination will compromise the preservation process. Typically, bottles and jars that have been pre-used (home industries) are washed with boiling water and dried under sunlight, in a microwave or in an oven. Larger factories will flush the jars with steam, even when these are new, unused containers.

On a small scale (up to 20 litres per day), the mango pickle is produced in a well-equipped kitchen.

3.4 Ingredients for success

3.4.1 Competitive production

Mango pickle from home industry suppliers or from Indian companies exporting to the rest of the world all rely on a relatively low cost of production. Indian companies specifically have access to the most extensive mango production in the world and a global hub for spices. As a traditional Indian product, they also have the advantage of being associated with authentic recipes. This makes it possible to produce and export very competitively.

On local markets there might be competition from home industry producers. In this case, large formal factories would need to develop a distribution model and potentially branding that gives an advantage over the home industry producers. This might be food safety, product quality, availability, packaging and pack sizes, or even focus on a different sales channel such as hotels and caters.

3.4.2 Spice quality

Spices are sourced globally, or from local suppliers. Both have disadvantages when it comes to food safety and contamination. Local suppliers of chilli, ginger or garlic in Africa have been known to use pesticides that are not suitable for export grade products.

On the other hand, imported spices can be contaminated in their country of origin or in handling and shipping. It is important to have control over the quality of the spices used in production. This might mean using reputable suppliers with good quality controls. For larger processors, this could mean heat-treating spices to ensure that they are free of contamination, pesticides, etc.

Contamination can also happen in the factory, especially where spices are bought in bulk, opened and used over several production shifts. In a factory, it is best to source spices in packs that are just large enough for each production batch. This will enable you to open a pack at the start of each shift and limit or prevent cross-contamination. This is also helpful in achieving a consistent product recipe.

3.4.3 Professional high-pressure management

Local formal picklers face stiff competition from home industries in the mango season. The processors are generally well known to their customers and rely on word of mouth to build awareness of their offer. At the same time, they do not have to pay marketing fees, or make allowances for retailer margins. Being able to compete means having very good control over pricing, but more importantly ensuring that you develop a recipe and production process that is highly stable and allows you to make the most of your sales out of the season.

This focus on the off-season provides for a longer sales period in a part of the year when there is virtually no other competition. But it does require a lot of working capital. It means that the processor needs to buy all of their raw materials in a 3-week window, then source packaging and pack over a few weeks or months. All of this money needs to be invested knowing that sales are more likely to dip over the season and that revenues will trickle in over a 9-month period before the next season begins. This model demands excellent cash flow, and organised sourcing and production. Warehouse management needs to be professional so that none of the stock built up in the peak season is lost.

3.4.4 Shelf-life management

Oil-based mango pickle has a shelf life of about 18 months. This is ideal for out-of-season sales. However, when stored under tough conditions, such as high heat and exposure to light, shelf life can be greatly decreased. The expected shelf life would then be 9 months, leaving the factory without sales precisely when they need to prepare for the coming production season. Having good control of warehousing is thus essential to extending the shelf life. Then sales can continue as long as possible throughout the year.

3.4.5 Semi-sterile packing and packaging equipment

The ingredients used in the pickling process all play a role in preservation of the mangoes as a pickle. However, without a clean environment, uncontaminated packaging and raw materials you will not be able to produce a product that has a long shelf life and guarantee food safety and shelf life. This is especially true of the packaging material, which should ideally be sterile.

4. Issues and opportunities

Table 1. Issues and opportunities

Issues	Opportunities
▪ Seasonality of mangoes and the short production season (3 weeks) ▪ Competition for raw materials ▪ High working capital requirements, with sales trickling in over the rest of the year ▪ Completion from home industries ▪ Low familiarity in many African markets ▪ Competition from Indian suppliers in the export market ▪ A few large brands ▪ Rising costs of oils	▪ Growing interest in ethnic foods ▪ Large Indian diaspora introducing Indian foods to new markets ▪ Relatively expensive product ▪ Innovation opportunities (low oils, spices, etc.)


SACLA
Prince
Tahini
MONINI
Classico
Delicato
Anfora
St. Michele

6 MANGO VINEGAR

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Contents

1. What is mango vinegar?

Vinegar is produced by fermenting sugary items such as fruit or wine. It is used as a flavouring agent in condiments or as a preservative in pickling. Vinegar adds a slightly acid flavour to meals, both in fragrance and flavour. It also "cooks" meals by dissolving their structures and softening their textures.

Cheaper vinegars can also be used as cleaning products, weedkiller (herbicide), etc. Such products are about 45% concentrated vinegar. Food grade vinegar is far less concentrated (4–5%).

Mango vinegar, which is a niche, speciality product is mostly used as a food grade dressing vinegar. As a result, it is used to flavour salads or as a marinade. Dressing vinegar comes in a variety of flavours including lemon, apple, raspberry, garlic and cherry. The mango vinegar on the market is typically a table or balsamic vinegar that has added mango purée for flavour. However, a 100% mango vinegar can be produced using standard vinegar processes, technology and ingredients.

2. Demand

The vinegar market is large and growing. Nearly €890 million worth was exported in 2021. Most vinegar in this year was imported by the USA, Germany, France, the UK, Canada and the Netherlands. Collectively they import 52% of global vinegar by value.[1]

Within vinegars and condiments, the demand for premium dressing vinegar has been growing[2], a trend that is expected to continue.

Mango vinegar is thus a small part of a very large market. Shoppers have many options available to them when it comes to dressing vinegar. They can use other fruit vinegars such as strawberry, they can opt for premium balsamic vinegars (original or flavoured), or they can opt for home-made or premium salad dressings. The mango vinegar segment is thus very small when compared with the very many vinegars that make up the vinegar market. In fact, it is almost invisible in most retail stores.

Image Source: www.amazon.com

2.1 Relative pricing

2.1.1 Food grade vinegars

Premium fruit vinegars are significantly more expensive than table vinegar, but they are not the most expensive vinegars on the market. In France, in one of the most developed vinegar markets, fruit vinegars are far more expensive (by volume) than table vinegar, but they are cheap when compared to artisanal speciality Italian balsamic vinegars. A raspberry or mango pulp vinegar in Carrefour France costs €23.96 per litre,[3] nearly half the price of an aged balsamic vinegar from Italy (see Table 1).[4]

Table 1. Comparative costs of white, fruit and balsamic vinegars, France

Product	White vinegar	Raspberry pulp vinegar	Mango pulp vinegar	Artisanal balsamic vinegar	Balsamic vinegar crème	Honey, garlic and thyme garlic	Traditional aged balsamic vinegar (12-year min. age)
Brand name	None	Elise Et Felicie	Elise Et Felicie	Elise Et Felicie	De Modène Bio Bionaturae	Le Rucher De Macameli – Bouteille	De Modene Aop
Price per litre	€0.40	€23.96	€23.96	€26.00	€34.33	€69.96	€226

Source: Prices from www.carrefour.fr (August 2022).

1 ITC Trade Map

2 www.coherentmarketinsights.com/market-insight/dressing-vinegar-and-condiments-market-3353

3 All price data are for August 2022.

4 The development of this market means that there were a variety of products and prices available for comparison.

The consumer price of mango vinegar does not seem to have a direct relation to the mango purée content of the vinegar. But seems to be set rather by the bottler, especially considering that the biggest share of most vinegar blends is white wine vinegar which is relatively cheap (see Table 2).

Table 2. Comparison of prices of mango vinegar across countries

Product	Mango infused vinegar	Mango pulp vinegar	Mango flavoured vinegar	Mango flavoured vinegar	Cameroon mango vinegar	Mango flavoured vinegar
Webstore	Our finest	Carrefour France	Oil vinegar online – Netherlands	The Artisan Food Company – UK	Piccantino World of Spices – Austria	Oil and Vinegar – USA
Price per litre	€10	€23.96	€39.80	€47.68	€52.45	€70
Mango purée content	Unknown, blend	Unknown, blend	32% mango purée blend	Unknown, blend	40% mango purée blend	35% mango purée blend

Source: Prices from online webstores indicated in the table (August 2022).

2.1.2 Industrial vinegar

Industrial vinegar is considerably cheaper than food grade vinegar. Industrial vinegar on Amazon retails at €5.70 per litre. This product is pure vinegar (100%), but diluted to 45%. As a result, the actual pure vinegar costs €12.54 per litre (see Table 3).

2.1.3 Competitive analysis

Mango vinegar in France costs €23 per litre for the finished, blended product. But it only contains 70% vinegar and is 30% mango purée. If we calculate the cost of pure vinegar, it €64.40/l at 100% concentration. By selling vinegar as mango vinegar, the product achieves a very high price. It appears that swapping out the generic vinegar with vinegar made from mango waste enables companies to achieve this high retail price.

Table vinegar in comparison is very cheap. It costs €0.40 per litre. This is typically at 5% concentration. So, if it was sold as pure vinegar the table vinegar would be €8 per litre. This is about an eighth of the price of the vinegar in mango vinegar (i.e. mango purée with vinegar).

Table 3. Comparative pricing on 100% pure vinegar

	Mango vinegar	**Industrial vinegar**	**Table vinegar**
Retail price per litre	€23	€5.70	€0.40
Pure vinegar content in the product recipe	70%	100%	100%
Vinegar concentration	5%	45%	5%
Price of 100% pure concentrated vinegar per litre	€64.40	€12.54	€8

There are a few conclusions we can draw from this analysis.

1. Food manufacturers are using the addition of purée to increase the perceived value of the white wine vinegar. This allows for higher prices of and better profits from a product that is usually very cheap. It essentially allows vinegar companies to sell white wine vinegar, made from just about any feedstock, for exceptionally high prices (in this case equivalent to €64.40 per litre at 100% concentration).

2. From an economic perspective it would be theoretically feasible to manufacture a 100% mango purée vinegar, i.e. without added white wine vinegar, which it could be very profitable. However, the very low price of white wine vinegar explains why so many food companies blend mango purée with white wine vinegar instead of making 100% mango vinegar – if they used the cheapest white wine vinegar available, the raw material would cost €8 per litre, then they could sell it for €64.40. It is very unlikely that they are in fact using the cheapest white wine vinegar available, but it does suggest that a vinegar made entirely from mango would have to be quite cheap to be able to compete. In this scenario, a competitive price would be between €8 and €12 for a processor to consider selling food grade pure (100%) mango vinegar to a bottler. But, the bottler would need to be convinced to spend considerably more than the current price they are paying for vinegar.

3. In all likelihood, a processor is better off producing industrial grade vinegar rather than cheap table vinegar. By concentrating the product and selling it for other uses, it achieves significantly higher retail prices than white wine vinegar, leaving better margins for all actors along the value chain.

4. There are major overlaps in the process used to produce vinegar and purée. Both processors would have to rely on sourcing third-grade fruit, which is in short supply in most African countries. For many processors it would be necessary to choose whether to use the fruit for juice or vinegar production.

Purée itself sells for €800 per tonne on the global market. This is not even the retail price, yet it is as expensive as cheap table vinegar to a retailer in Europe. Industrial grade vinegar fetches higher prices. At the retail level, however, this is only 25% more than the global price of mango purée. The opportunity cost of producing 100% pure mango vinegar instead of purée from damaged fruit could therefore be too high.

2.1.4 Local variety production

It might be possible to use local mango varieties for vinegar production. These tend not to be a part of an organised collection system, which would therefore need to be developed. A second challenge is that many local varieties bruise easily, or they are very fibrous. Both issues could result in high losses. First, bruised fruit is more likely to rot so would need to be sorted out at the first stage of production. Second, fibrous fruit yields less fruit pulp. As a result, vinegar processors would face many similar costs to purée processors. For example, logistics costs, processing costs, packaging costs and labour costs would all be similar. Processors would need to be certain that a lower cost of fruit justifies the higher losses from bruising and higher fibre content.

It is more likely that vinegar processors would have a better business case for using purée as a raw material rather than collecting their own local varieties of fruit. But this would need to be confirmed through a more thorough economic analysis.

2.2 Buying criteria

2.2.1 Acidity

The acidity of food grade vinegar is carefully monitored. If it is too acidic, it is unpleasant. But vinegar that lacks acidity has a shorter shelf life. Vinegar should have an acidity of between 3.5% and 7%.

2.2.2 Fruit pulp

A premium mango vinegar, at least the final finished product, tends to have a purée content of more than 30%, but this can be as low as 10%. This adds colour, flavour and aroma.

Table 4. Characteristics of food grade mango vinegar

Characteristic	Target	Note
Acetic acid	3.75 g / 100 ml	Range 3.75–7%
Total solids	1.5%	
Pulps or fruit content	>10%, but typically 30%	For pulpy fruit vinegar

2.3 Market trends

2.3.1 Natural cleaning products

Cheap fruit vinegars, typically white wine vinegar, are being used to mix natural cleaning products at home. The product is valued for being less toxic than bleach or other, often heavily fragranced, cleaning solutions. If a cheap mango vinegar is made it would compete in this growing, but low-value category.

2.3.2 Whole foods, plant based

The whole foods, plant-based way of eating focuses on introducing lots of fruit and vegetables into one's diet. Those who follow this way of eating enjoy lots of salads. As these people prefer unprocessed foods, they also mix their own salad dressings. Fruit vinegar, especially those with rich fruity flavours and aromas, are valued in this market. This offers opportunities for vinegar bottlers.

2.3.3 Flavour and organic innovation

Shoppers are increasingly interested in enjoying novel flavours in their foods. This extends to flavoured vinegars. Shallots, apple, tomato, fig, garlic, mango and berries are just some flavours that are being introduced or becoming more available in stores (online and physical).

2.3.4 Natural and organic

New products being introduced in the premium vinegar market tend to be preservative-free and make use of natural flavours from fruit purées, herbs, etc. In some premium vinegars, such as coconut and apple cider, organic is becoming an interesting innovation area. This could offer opportunities for producing an organic mango product.

2.3.5 Oil and vinegar boutiques

The interest in natural oils and vinegars has resulted in an increase in specialist shops selling natural, premium vinegars. This is introducing more affluent shoppers to fruit vinegars such as mango vinegar. This could point to further growth in this product.

Images sourced in this chapter are from www.unsplash.com

3. Supply

3.1 How do these products reach the market, what is the value chain structure?

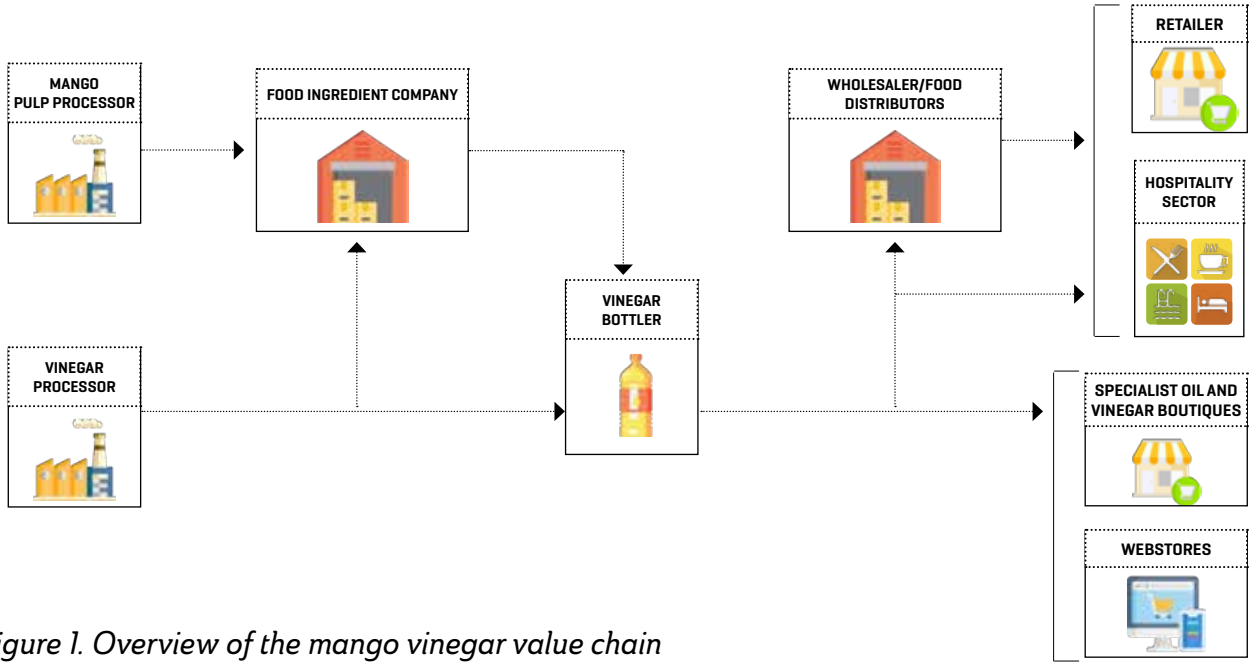

Figure 1. Overview of the mango vinegar value chain

Vinegar bottlers play an important role in the vinegar value chain – especially for premium vinegar sales. These companies blend white wine vinegar with mango purée to create a distinctive flavour. They are also the value chain actors who will determine the amount of mango purée and vinegar will be used in the recipe. Lastly, they determine the quality and hence the price of the cheaper vinegar product and whether this is made from grapes, sugarcane or eventually mango itself.

Food ingredients companies are the most likely suppliers of mango purée to vinegar bottlers in premium markets. This is likely to remain the situation. However, if vinegar bottlers can be convinced to replace generic white vinegar with vinegar made from mango waste, there are opportunities for the vinegar supplier to sell directly to the bottler. Food ingredients companies might also play a role as an intermediary. But the bottler would need to be convinced that this is a viable idea. Using a vinegar made from mango waste needs to be beneficial, for example, having better flavour, health claims, price or some other benefit.

Vinegar bottlers have several options when it comes to selling their product. It can be sold directly to specialist oil and vinegar boutiques, via webstores or to the hospitality sector. Alternatively, they can work through wholesalers or food distribution companies. The premium prices of mango vinegar do mean that many are distributing their product via online stores that specialise in premium food products.

3.2 Technology, processes and techniques

3.2.1 Production process

The process is relatively simple, albeit lengthy. It also requires meticulous attention to bacteria and fermentation control. This is described below (see Figure 2).

Figure 2. Production process for mango vinegar

Stage 1: Reception of raw materials

In this stage the mangoes are cleaned and prepared for processing. The mangoes are washed three times to remove any residual pesticides and dirt. The fruit is then destalked, removing the bitter part of the stem that joins the fruit, and 90% of the peel is removed. This all ensures that the fermentation process is controlled, and that the final product is not bitter. As in purée production, third-grade mangoes can be used for vinegar production. However, at this stage sorting is required to ensure that fruit that is rotting or is still not ripe is removed from the production batch. Both affect the quality and concentration of vinegar that can be produced. Rotting fruit introduces unknown bacteria into the pulp, while unripened fruit is too low in sugar to fully feed the fermentation process.

Stage 2: Pulping

In this stage the fruit is removed from the stone and mango pulp is created. This pulp is called a mash in vinegar production. It is created in a similar fashion to premium mango purée: the mango flesh is removed, and the stone might be scraped to remove remaining flesh. All the mango flesh is placed in containers to soak in 1–4% vinegar water. This prevents browning of the mango, prevents harmful microorganisms from growing and prepares the product for fermentation. Water is then added so that the final product is about 10% water. This is then agitated (stirred) and pressed to release juices and break up the flesh. It is then strained to remove the fibrous part, leaving a concentrated slurry. For a pulpier vinegar, a coarser strainer would be used, allowing more pulp through the strainer and only holding back the fibres.

Stage 3: Pasteurisation

In this stage the liquid is readied for a controlled fermentation process. Sterilisation can take place at this stage.

Stage 4: Double fermentation and ageing

In this stage the liquid is fermented twice. In the first fermentation the sterile slurry is placed in fermentation tanks. Water is added so that it is 20–25% of the mixture, i.e. a ratio of 1:4–1:5. Yeast is added as well as small mounts of salt and sugar. The fermentation tanks' necks are then covered with muslin cloths and aerobic fermentation takes place for 15 days at 30°C (alcoholic fermentation).

After 15 days the yeast on the surface is skimmed off. This helps to keep the vinegar clear. The vinegar is then aged by allowing it to stand aerobically in a sealed state for 15 days (acetic fermentation).

Stage 5: Sterilisation, packaging and shipping

The vinegar is then sterilised by heating it to between 50°C and 60°C for 10–15 minutes. If a final product is being produced, this can be mixed with a mango purée and then bottled. If the product is to be sold in bulk as a low-cost vinegar or an industrial vinegar, then this can be packed into bulk packaging, i.e. double-lined drums.

4. Ingredients for success

4.1 Low-cost mango

To make this model work, the investor needs to be able to access mangoes that are either third grade or are not being used in other applications such as juice or dried fruit. This is challenging in many African countries where mango is expensive and in great demand. Alternatively, local varieties – typically referred to as short- or long-nosed mangoes – might not be suitable for the processing sector. They tend to be damaged more easily, have higher fibre content, or are too small to deliver enough pulp versus the skin and stone – they could have potential as a raw material for vinegar production.

Investors will need to carefully assess the opportunity, keeping in mind that it is technically possible to use mango purée as a raw material for vinegar production. It is also possible to use investment capital to produce mango purée, which is in demand and can be sold at higher prices than mango vinegar.

4.2 A willing buyer

Mango vinegar currently relies on white wine vinegar. So, for a change to be made a processor using 100% mango as a feedstock would need to find a buyer who values a pure, mango fruit vinegar. There are examples of premium balsamic vinegars that have good distribution in French supermarkets and speciality vinegar stores. So, this is challenging, but it could still be possible.

4.3 Local premium niche market

This is crucial to being able to fully assess whether there is indeed an opportunity to produce mango vinegar at all. This could be a niche product in a local or regional market. But this hinges on being able to get distribution of the product via urban supermarkets or local webstores. This is happening in Ghana, but on a very small, artisanal scale.

5. Issues and opportunities summary

Table 5. Issues and opportunities

Opportunities	Issues
▪ Growing demand for premium dressing vinegars and natural cleaners made from vinegar. ▪ Very high prices of mango vinegars, enabling premium prices for the vinegar base.	▪ Mango vinegar tends to be made of a white wine vinegar, blended with a purée. This is very affordable and profitable for vinegar bottlers. ▪ Table vinegar is very cheap. ▪ Industrial vinegar uses cheap feedstocks such as sugarcane rather than expensive mangoes. ▪ Local varieties are unlikely to be more profitable than using purée as a raw material because of losses to damage and fibre. ▪ Small local market for premium dressing vinegar.

6. Conclusion

The opportunity cost of producing vinegar from third-grade mangoes is that processors could be using that mango to process purée – economic analyses suggest that purée fetches higher prices than both table vinegar and industrial grade vinegar on the global market.

Local varieties that are not in demand for juice production could offer an opportunity. But this depends on the fibre content of the varieties. If they are too fibrous, too little juice might be created and too many solids lost to make the product economically viable.

It is economically feasible to manufacture a finished premium mango vinegar for export. However, it is important to ask whether companies that (plan to) do so will be able to compete. Processors in Africa would need to compete with companies bottling a range of vinegars in Europe. These companies use cheap vinegar, blended with purée and face lower shipping costs. If companies in Africa opt to sell premium mango vinegar locally, they will face challenges in marketing an expensive product to a small market and through a limited number of stores. The high price suggests that is likely to remain a niche opportunity, but one that needs effort and investment to generate sales and distribution.

The larger industrial vinegar market does exist. But it asks processors to compete against vinegar products that are made from sugarcane and other feedstocks that are cheap and plentiful. Here too, processors could be using the mango pulp to make purée, which has a higher sale price.

The mango vinegar opportunity is thus unlikely to be truly viable. In nearly every scenario, an investor is better off producing purée instead of vinegar. Ironically, this offers a better opportunity of being able to supply product to premium vinegar dressing bottlers.

7 MANGO BUTTER

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Contents

1. Mango butter

1.1 What is mango butter?

Mango butter is an oil that has been extracted from the seed of the mango. It is also known as mango kernel butter. Like shea and cocoa butter, it is a light oil that melts when slightly warmed. Mango butter is sometimes used as an ingredient in skin care products such as lotion, face cream, soaps, body butter or lip balm.
Like shea or cocoa butter, it is possible to use mango butter as an ingredient in foods such as chocolate or other snacks, but this is rare.

Source: www.*isvunonaturals.com*

1.1.1 Cocoa butter and animal fat replacement

Mango butter has similar properties to cocoa butter and can replace cocoa butter in chocolate. The EU allows up to 5% of cocoa butter to be replaced by other butters. Shea butter often replaces cocoa butter; Cocoa Butter Equivalent (CBE) is the biggest market for shea butter.

The USA does not allow cocoa butter substitution. Other countries, including some in Asia, do allow substitution. This is a particularly relevant issue as there are shortages in the global cocoa butter market. Mango butter can also be used to replace margarine and other animal fats in recipes for desserts and baked goods.

1.1.2 Oils in nutraceuticals

Mango butter is rich in vitamin C and other nutrients that research has linked to improved collagen synthesis in the body. Mango butter is currently a popular ingredient that has received significant attention from various companies supplying supplements.

1.1.3 Oils in cosmetics

The texture, low melting point and vitamin content of mango butter make it an interesting ingredient for cosmetics and personal care products. Mango oil is used in products such as lotions, face moisturisers, shampoos and lip balm.

2. Demand

2.1 Market size

Mango butter is a relatively new product on the market. It has a high price, which may hamper its growth potential. Nevertheless, according to several studies, the mango butter market size was valued at US$100.4 million in 2019 and was projected to reach US$163.4 million by 2027. This is a growth of 13.0% from 2021 to 2027.[1]

Most of the demand is driven by interest from the personal care industry, particularly in North America and Europe, which are currently the largest markets for mango butter. However, the demand for natural cosmetic products in the Asia-Pacific region is expected to grow.

Technological advancements have helped producers of mango butter in Europe to refine mango butter, so the mango butter market in Europe is witnessing considerable development.

2.2 Market trends

2.2.1 Novelty and trends

Several studies suggest that the demand for mango butter will grow. However, demand for ingredients such as aromas and oils in the cosmetics industry is very trend-driven. Demand in one year can spike, only to be followed by a fall in the next year. For example, woody fragrances can be very popular, only to be replaced by cleaner, fresher fragrances in the next year. This is how cosmetics companies drive interest in the category. However, it can be problematic for processors, who might have to develop a supply chain in order to satisfy market demands. Currently, mango butter satisfies many popular market trends, but it is important for processors to consider whether these trends will be sustained. If they are likely to be short-term trends, investors must decide whether this justifies investment.

Source: Brand website

2.2.2 Clean beauty

Source: skyorganics.com

Shoppers are increasingly seeking out cosmetic products that claim "natural" credentials. Many beauty companies are replacing artificial colours and fragrances with natural oils and vegan and organic ingredients. Raw mango butter is particularly interesting in this trend as it offers a natural, minimally processed product. It can also claim to be vegan, is not tested on animals and, depending on the source of the mango seeds, may be organic. These qualities may be beneficial for both marketers and processors.

1 Allied market research (2020). Mango Butter Market by Type (Refined and Unrefined) and Application (Food, Cosmetics, and Pharmaceutical): Global Opportunity Analysis and Industry Forecast, 2021–2027. https://www.alliedmarketresearch.com/mango-butter-market

2.2.3 Floral fragrances

Floral fragrances are currently an important fragrance trend. These fragrances may appeal to a sense of nostalgia or tradition among consumers. Currently, these products are taking up more space on retail shelves, reducing opportunities for fruity fragrances. This is another example of the unpredictable nature of the cosmetics and personal care category. This possible risk needs to be considered by potential investors.

Source: The Body Shop

2.2.4 Responsible citizenship

Becoming a "good global citizen" is a trend that is currently affecting many product categories. This trend includes the desire for vegan products that are made sustainably. There is also a desire for more inclusive products, whether from the perspective of gender, sexuality or general economic welfare. Processors of mango butter who can offer positive sustainability stories might have an advantage over companies that cannot offer these benefits.

Source: The Body Shop

2.2.5 Mango blends

Mango is most often sold as a raw or unblended product, while mango oil is often blended with a variety of oils in the final product. However, this is not always stated on packaging. Where blends are stated, they tend to be combinations of tropical fruits or nuts. Some popular blends claimed on product packaging are coconut, shea, mandarin, papaya and marula.

Source: www.petalfresh.com

2.3 Certifications and quality standards

2.3.1 Visual

Clear butter with no visible impurities or unpleasant smells. Easily spreadable once heated.

2.3.2 Packing

Mango butter can be purchased in a range of sizes. The smallest pack size is 20 kg, although volumes can be as large as 36 tons. Some common pack sizes for export are:

- a 20 kg bucket
- 25 kg box
- 190 kg drum
- an Intermediate Bulk Container typically holding 1 ton
- an ISO (International Organisation for Standardisation) tank, which can hold up to 36 tons of product.

2.3.3 Certifications

There are no specific required certifications for mango butter. However, to achieve a competitive advantage it may be useful for producers to consider several certifications that are being used by beauty companies. These include product certified by the Soil Association, artisanal production, fair trade, rainforest alliance and organic certifications.

3. Supply

3.1 How do these products reach the market?

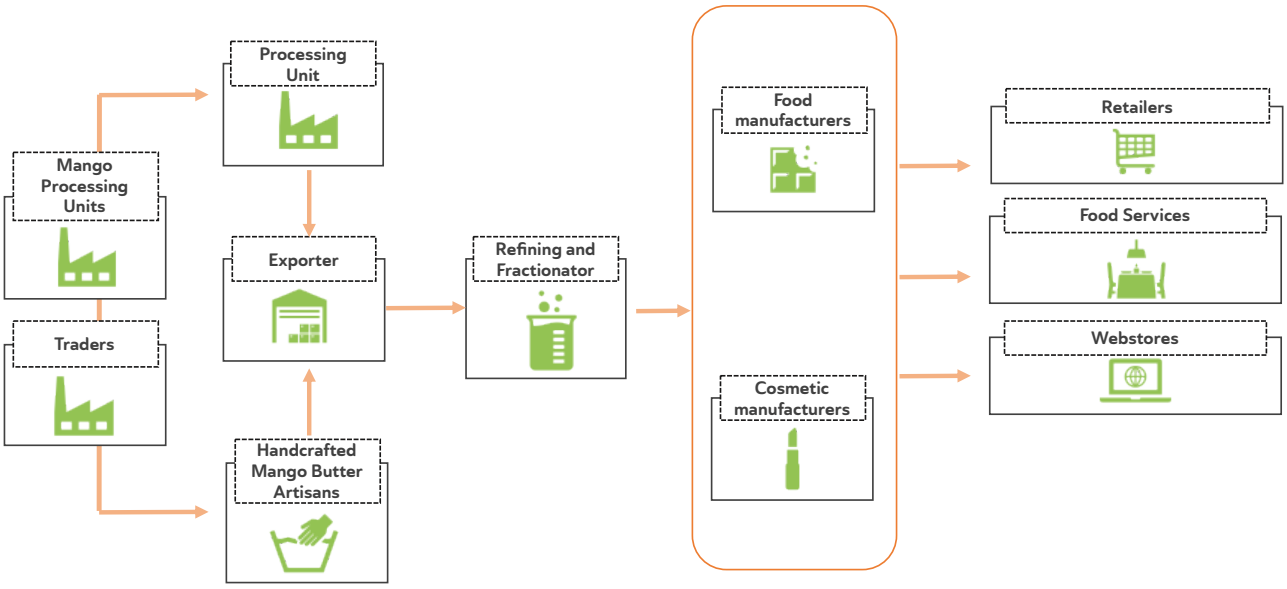


Figure 1. Overview of the mango butter value chain

The value chain for mango butter (Figure 1) is similar to those for other nut butters such as shea or cocoa butter. However, as mango butter is made from the mango seed (waste from mango processing units), the seeds need to be collected and taken to a second processing unit. The processing company extracts the oil from the seed and sells the raw mango butter to an exporter. Mango butter can also be pressed by small-scale artisanal processors.

The more complex process and the specialised knowledge required to successfully extract oils from mango seeds means that there are relatively few companies that extract oils in this way, especially in Africa. Monorama in India is perhaps one of the few companies currently extracting mango oil for the global market. Monorama is able to do this because the company extracts a variety of different oils, such as shea and cocoa, as well as oils from local seeds such as *kokum* and *sal*.

In most parts of the world, mango butter is pressed mechanically. The raw butter is consolidated into batches that can fill a container, then shipped to a refinery, which is typically in a developed market such as the Netherlands or Germany. The raw mango butter is then processed further so that it is smoother and ready for use in cosmetics or food products.

3.2 Main suppliers of mango butter

India is a major mango growing country and the origin of most of the mango butter sold on global markets. Production of mango butter in India is largely manual. Cooperatives tend to arrange for collection of mango seeds from the wild. They then sort, sun-dry and crack the mango seed so that the kernel can be removed. These are then supplied to processing facilities equipped to extract the oil.

The USA and China are also large suppliers of mango butter.[2] However, in the case of the USA this is because of refining capabilities that enable companies to refine raw mango butter.

In most oils and fats, the higher margins can be found closer to the consumer. The butter extraction often attracts the lower margin, whereas companies who refine fats tend to have higher margins. Fractioning of fats into separate compounds such as olein and stearin is technologically more complex and tends to attract even higher margins. The more complex refining and fractioning is often done in the US and Europe, whereas extraction is increasingly carried out closer to source in developing countries.

3.3 Pricing

It is difficult to obtain reliable pricing for any commodity that is new and has relatively low trading volumes. Furthermore, the prices obtained may only be theoretical prices, because that price would not attract a buyer in practice. An exporter may offer a price based on their cost-price and margin, but because alternatives are much cheaper, few if any buyers may be willing to purchase at that price. Often, it is necessary for a new product to be priced close to or lower than the product it can substitute for in order to obtain a decent market size.

3.3.1 Foods

The closest substitutes for mango butter are shea butter and cocoa butter. Like mango butter, both can be used in cosmetics and food.

There are three types of shea butter:

- Artisanal butter for the regional West African market
- Artisanal and partly refined butter for the international cosmetics market; often organic and fair trade certified
- Shea butter that is industrially produced with the use of solvent extraction plants. This butter is often fractioned into olein, stearin and latex and can be considered equivalent to cocoa butter.

2 https://www.cbi.eu/market-information/natural-ingredients-cosmetics/mango-butter/market-potential

As industrial shea butter is a substitute for cocoa butter used in chocolate, its market prices roughly follow cocoa butter prices and may therefore indicate competitive prices for mango butter suppliers aiming to establish themselves in this market.

Cocoa butter prices in are, on average, very close to cocoa bean prices. This is because about 50% of the bean is butter and the other 50% solids (cocoa powder). The 2022–2023 cocoa bean price is around €2 per kg, which also seems to be the average price over the past 5 years (Figure 2). This would be a competitive price for mango butter.

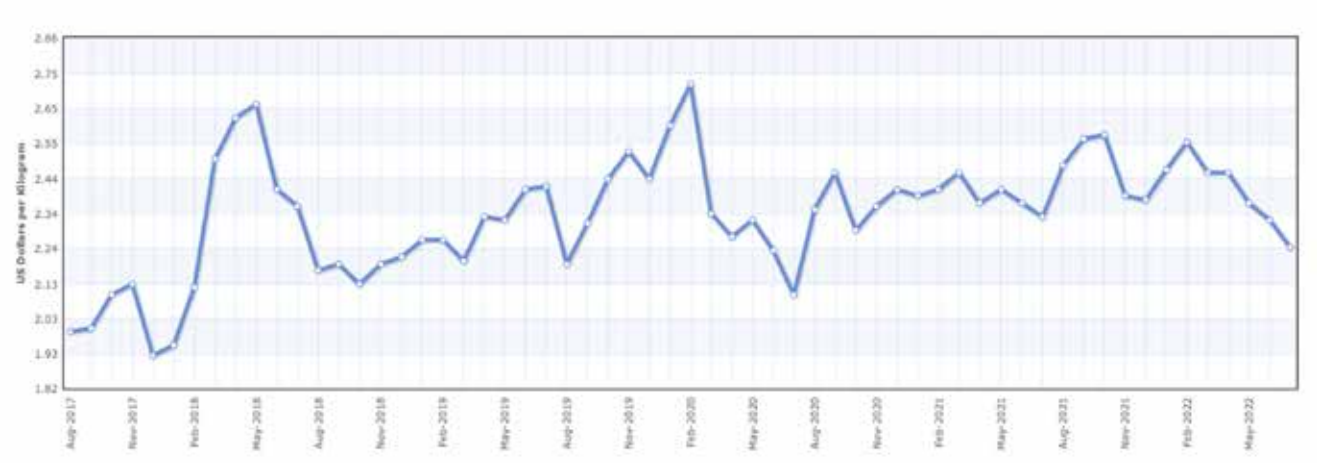


Figure 2. Global cocoa butter price: Aug 2017–May 2022
Source: www.Indexmundi.com

3.3.2 Cosmetics

Premium refined oils for cosmetics are purchased by cosmetics companies from fragrance and ingredients companies for as much as €32 per litre. Refined avocado oil, for example, which is a small premium market that is similar to the mango butter market, is sold for about €32 per litre to cosmetics companies.

These sales prices need to accommodate transport and logistics costs, as well as the processing costs (in the EU, USA, etc.). As a result, the prices of mango butter are likely to be 30–50% of this sales price. This suggests that mango butter will be priced at about €8–24 per litre in supplying countries, depending on the quality and the marketing story that can be developed for the product.

Table 1. Comparative oil prices

	Raw cocoa butter	Raw shea butter	Refined avocado oil
Price per litre	€2 per litre	€2 per litre	€32 per litre (to manufacturers)

The prices for cosmetic-grade mango butter could be high. However, even if this product can gain a foothold in the market, sales volumes may be limited and demand could be temporary.

3.3.3 Competitiveness

Foods and nutraceuticals

To compete in the foods sector, suppliers will need to offer cocoa butter buyers reliable volumes that can make a difference to their supply needs. At the same time, the product will need to be as affordable as shea butter, which is sold for about €2 per litre.

3. Supply

Cosmetics

About half of the mango butter traded globally, a value of around €16 million per year, is used in the cosmetics sector. If the final sales price is indeed €32 per litre, then roughly 25 twenty-foot containers of mango butter per year are sold for cosmetics. At half this price, 50 containers – or 4 per month – of mango butter are being shipped globally for cosmetics purposes per year. This suggests that this is a small but high-value market.

There are hundreds, if not thousands, of essential oils and butters on the market that can be used in cosmetics. While they are all unique, many can be substituted for another similar oil.

Most cosmetics products have a blend of cheaper functional base ingredients that remain more-or-less constant over time. Premium oils or fats are then blended into the base recipe for specific fragrances, hand-feel or other properties, and to create variety and new marketing stories. Premium oils such as shea, rose, rosehip, lavender extract, citrus oil, cocoa butter or mango butter are used sparingly. So, a single product – even one that is labelled as being mango butter lotion, for example – might only contain a small amount of mango butter. This is a common strategy for manufacturers who are attempting to keep the product affordable.

These premium ingredients also need to be swapped out to create new and interesting products and ranges year after year. Each cosmetics range will likely keep the best sellers or classics for a longer period, but about 70% of the assortment will be replaced every 2–3 years. This means that, for many oils, demand is likely to be very trend-driven – rising when the ingredient is popular and then quickly falling when the trend declines.

Mango butter is used sparingly due to its high price. If it does not become more popular, as is the case for many oils, it is likely to be swapped out for a new, more popular oil after a few years. The low volumes also put it at risk of range rationalisation. Most companies prefer to limit the number of ingredients they stock, as a large number of ingredients make supply chain management complex. After several years, companies tend to remove niche ingredients that are not very popular, or that can be replaced with a more standard ingredient. Mango butter would be a typical ingredient facing such a cut, if it does not become more valuable as a marketing tool.

Mango butter, when used in such small quantities, requires a major increase in demand for final products for it to earn its right to remain in a company's range of products. A container of raw mango butter can be used to create many units of final product, such as lotion or body butter. If a manufacturer such as the Body Shop purchased a 20-foot container of mango butter, they would receive about 20 tons of product. The Body Shop produces mango butter that is sold in 200 ml pots. If the recipe used 10% mango butter, they could produce 2 million units of mango butter from a single container. Hair products would use even less mango butter. If the recipe used 5% mango butter, 4 million units of final shampoo could be made from one 20-foot container.

A chain store such as the Body Shop has 3,000 stores globally. This means that each store, on average, would need to sell 666 units of body butter to use all the mango butter from a single container. Roughly 1,333 units of shampoo would need to be sold in their stores to use up a container of raw mango butter. Clearly, a very large amount of final product can be produced from a single container of mango butter. It is unsurprising, then, that most experts estimate that the cosmetics market buys only 5% of the export volume of shea butter. Most shea butter is used in foods. This is also likely to be the case for mango butter.

3.4 Production: processes and techniques

Mango butter can be extracted from the mango kernel using either mechanical or chemical (solvent) extraction, often with hexane. Solvent extraction is technically complex and requires far higher investments compared to mechanical extraction. However, chemical extraction produces far more oil than mechanical extraction from the same amount of mango seed.

Mechanical extraction is chemical-free, which has some advantages from a safety perspective. It also makes it easier to sell the product as a natural ingredient. Solvent-extracted product can probably not be sold as organic.

Figure 3. Production process for mango butter

3.4.1 Stage 1: Collection or reception of raw materials

There are two main models of sourcing: collection of waste at the village level and sourcing of waste from processors. The village collection model is used by the largest Indian processor of mango butter.
The mango seeds are received and washed at the factory. A fruit and vegetable bubble washer is recommended, along with chlorinated water. This machine allows for better washing and helps to kill bacteria that might contaminate the seeds. The water should be replaced every 3–4 hours.

3.4.2 Stage 2: Dehulling and grinding

After washing, the seeds are typically sun dried to reduce the moisture content to 12–15%. The seeds are then roasted in a drum roaster. The hull of the seed is removed either mechanically using a deshelling machine, or manually by beating the seeds with wooden clubs. The kernel is then ready for oil extraction.

3.4.3 Stage 3: Oil extraction

Oil extraction can be carried out mechanically or chemically.

Mechanical extraction

The kernels are put into a screw press, which presses the oil out of the kernel. The oil seeps through small openings that do not allow seed fibre solids to pass through. Between 4–5% of the original weight can be extracted, which is roughly 30–50% of the total oil content of the seed. A hydraulic press can also be used (see 3.5).

Next, the pressed seeds are formed into hardened cakes that are removed from the machine. The pressure involved in the expeller creates heat in the range of 60–99°C.

Chemical (solvent) extraction

The separated kernel pieces are crushed into small pieces in a hammer mill. The pieces are then fed through a pelletising machine, where pellets are created. The pellets are cooled in a chiller until they reach room temperature. The pellets then undergo solvent extraction with hexane. This method removes two to three times as much oil as mechanical extraction.

3.4.4 Stage 4: Storage and shipping

The oil is then poured into a high-quality, insulated, edible-oil storage tank. This is sealed and stored ready for shipping.

3.5 Technology

A hydraulic press is a machine that generates a compressive force. The pressure throughout the closed system is constant. One part of the system is a piston acting as a pump, with a modest mechanical force acting on a small cross-sectional area; the other part is a piston with a larger area that generates a correspondingly large mechanical force.

Source: India Mart website

High-quality, insulated, edible oil storage tank for storing the end product.

Source: https://gusumachinery.en.made-in-china.com/product/keywordSearch?word=edible+oil+tank&org=top&searchType=3

Dehulling machine: Used for separating the kernel from the shell.

3.6 Production economics

The mango seed is about 20–25% of the total weight of the mango. The kernel inside the seed is then 45–75% of the total weight of the seed. Just 12% of the kernel is oil, so processing 10,000 kg of mango seeds would result in 40.5–45 kg of oil (Table 2). There are also some losses in the process, which could make the resulting volume of oil produced lower than this estimate.

Table 2. Conversion from mango seed to oil using mechanical extraction

Item	Mechanical extraction	Chemical extraction
Initial mango weight	10,000 kg	10,000 kg
Seed weight	2,000 kg	2,000 kg
Kernel weight	900 kg	900 kg
% of oil recovered	4.5–5%	12%
Total oil weight	40.5–45kg	108 kg
Price per litre	€2.00–2.75 (shea-cocoa prices, for large sales volumes) €8.79–12.00 (current market price with limited volumes)	€8.79–12.00
Revenue from oil sales	€80–540	€216–1,296

As mango seeds are relatively light, sun drying this volume of seeds is time consuming and requires a significant amount of space and organisation.

In much of Africa, the harvest time for mango is also during the rainy season. This means processors need to dry large quantities of seeds in driers, adding additional cost to the oil production process. However, only €395–540 of revenue can be earned for processing the original 10,000 kg of seeds. This is likely too costly, as it would make an expensive, niche product uncompetitive in all but the rarest circumstances.

4. Ingredients for success

4.1 Sun drying

Machine drying the seed increases costs and makes the process expensive. Being able to sundry the seeds is thus an important ingredient for success.

4.2 Economic and logistical challenges

The logistics and economics of production make mango butter a difficult investment opportunity. From a logistics perspective, drying seeds in the rainy season is challenging and requires costly equipment such as continuous belt driers. Mango kernels also have a relatively low oil content. Oil processors thus need to process large volumes of seeds to extract relatively little oil. Even with high prices of mango butter, there are real questions about the ability of this type of business to support the necessary staff, equipment and drying costs.

4.3 Issues and opportunities

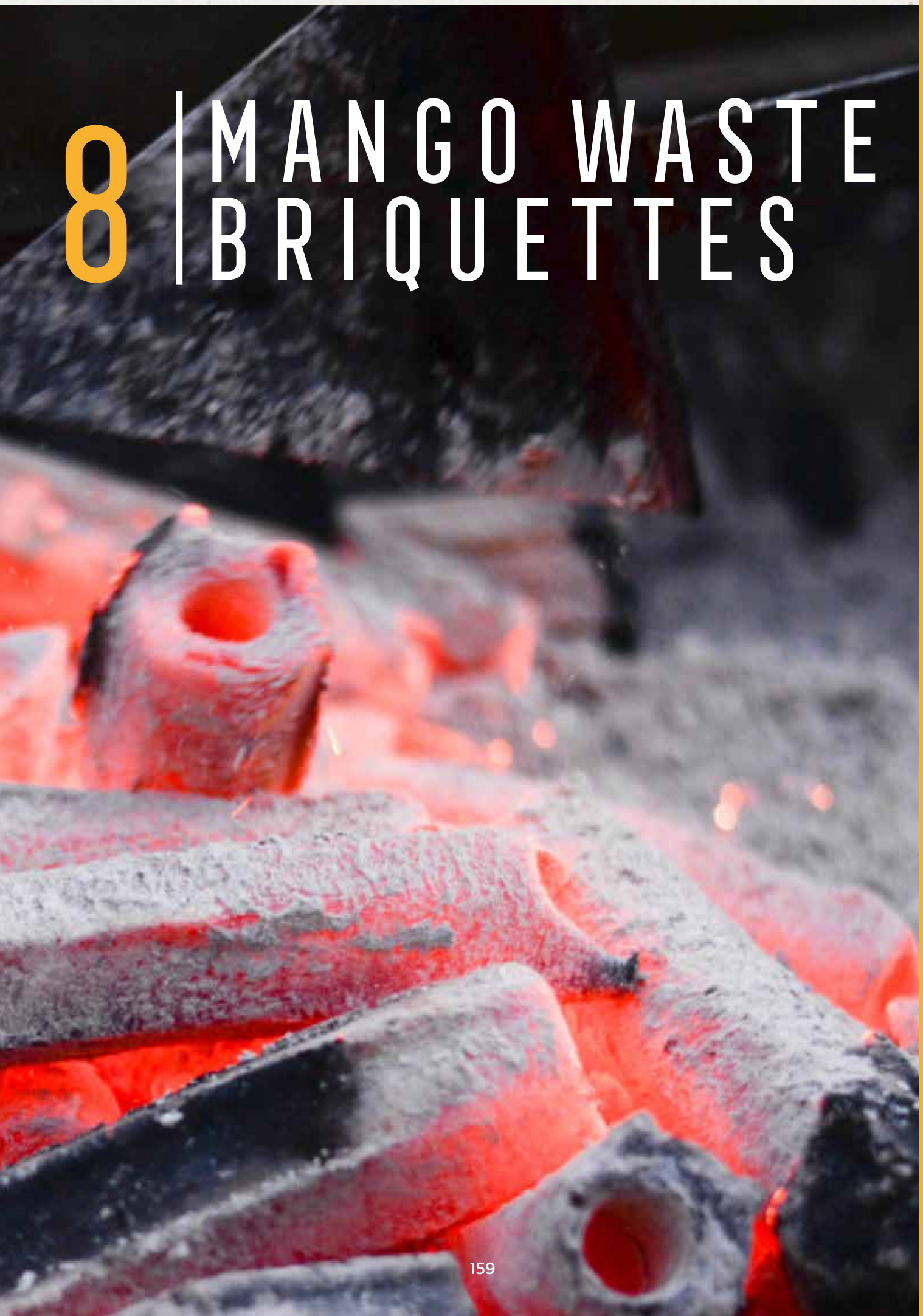
Table 3. Issues and opportunities

Opportunities	Issues
▪ Growing demand for mango butter for cosmetics, as a cacao butter replacement and for pharmaceuticals ▪ A trend-driven cosmetics market creates opportunities ▪ Demand for cocoa butter replacements in the EU and other parts of the world ▪ High revenue per kg of mango butter in the best circumstances.	▪ Unreliable demand from season to season ▪ Processing of oil likely to be during the wet season ▪ Costly drying equipment is needed for reliable drying of the seeds in the wet season ▪ Mango seed delivers a low volume of oil for very high volumes of raw material (seeds) ▪ Added cost of drying using dryers would make this uncompetitive ▪ A trend-driven cosmetics market- creates opportunities, but also means that demand can suddenly disappear.

5. Conclusion

Although mango butter is a premium product, with some existing demand in western markets, entering the mango butter market could be too challenging for most African investors. While the raw material – mango seed – is a waste product, and therefore inexpensive, the necessary investment to successfully produce mango butter requires a company to answer several critical questions: how can the seeds be economically dried during what is likely to be the rainy season? How can the company efficiently process the tons of waste required to produce relatively small volumes of mango butter? Will the relatively high price of mango butter on the global market justify the logistics, drying and investment costs? And will mango butter withstand the up and down trends that are a common feature of cosmetics and personal care products?

8 | MANGO WASTE BRIQUETTES



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This chapter has been produced with the financial support of the EU and the OACPS. Its contents are the sole responsibility of COLEAD and can under no circumstances be regarded as reflecting the position of the EU or the OACPS. (more information).

Contents

1. What are mango briquettes ?

Briquettes are made from mango waste. They are an alternative source of fuel to electricity, gas or even wood. They are used as fuel in homes for household stoves. In industry, briquettes are used as fuel for boilers. These briquettes can be made from a variety of agricultural waste, which is made denser and then dried, after which they are ready for burning.

Mango briquettes are a new option. These briquettes – in the few instances when mango briquettes have been made – use the inner kernel of the mango pip as the core ingredient. The mango kernel is crushed and dried, before adding a binding agent. It is then pressed into shape.

2. Demand

Energy is a major challenge in much of the developing world. In Africa, access to electricity remains a privilege: 645 million Africans have no access to electricity. In most of the Southern African Development Community (SADC), roughly a third of the population does not have electricity.

Electricity supplies can also be unstable. Power outages are regular occurrences in many countries. It is no surprise then that electrification, sustainable energy, LPG (liquefied petroleum gas) and other fuel source projects are on the agenda of many governments and development agencies across the continent. These projects face significant challenges. Shortages of funding and even electricity poles in many countries place the ability to expand the power grid fast enough to meet demand into doubt.

Households and industry are thus challenged to find their own solutions to their energy crisis – at least in the short term.

2.1.1 Household use

Firewood is still the dominant fuel used in rural areas. It is usually gathered by women and children, and therefore perceived as being free. Any product that needs to be purchased will struggle to compete with firewood, despite its many disadvantages. These disadvantages are mostly the time lost in finding wood and transporting it home, the time needed to prepare a fire, the smoke and dirt. However, none of these things primarily impact men who are often the main decision makers in rural households.

Poorer peri-urban and urban consumers tend to use charcoal, which needs to be bought. This is the primary space where mango briquettes can compete – if they are cheaper, burn better and longer than charcoal, or are easier to use.

More well-off urban consumers tend to cook on gas or in some cases electricity, and converting those back to open fires will be difficult. Gas is much easier to use. However, if briquettes would be much cheaper, they could perhaps substitute a small part of gas. The current record high gas prices would potentially help.

Over the past decade there has been a large shift in many countries from firewood and charcoal to gas. This is because charcoal is becoming more expensive as wood becomes scarcer due to deforestation. Charcoal makers need to travel further which increases cost. Gas is also increasingly subsidised and promoted to convert people away from charcoal. For example, in Ghana the market share of gas increased from 2% in 1995 to 25% in 2020.

2.1.2 Street vendors

Another market for briquettes would be street vendors, who normally prefer softwood charcoal that is easy to fire up for quick food preparation.

2.1.3 Industrial application

Finally, there is an industrial market. Many food processing plants require hot water, steam or heated air. This is generated in industrial boilers. In this market, mango waste would compete with cashew shells, coconut husk, firewood, sugar cane waste, rice husk and other biomass. For this market, flames, odours and ease of burning are less important, because the fuel is added to a continuously burning large fire inside a fire box. Pressing mango waste into briquette shape is not necessary either. Calorific value and cost are the most important factors, along with residues after burning. However, price is a major barrier, as most biomass currently used can be obtained for free. The costs are also limited by transport cost. Most rice mills and cashew plants do not know what to do with their waste.

2.2 Relative pricing

Briquettes are a direct substitute for charcoal. Thus, to gain market share the product needs to offer the same performance at a lower price, or better performance at the same price. However, in vast parts of Africa, charcoal prices are so low that it may be difficult to compete. The cost of producing one tonne of briquettes in Africa is up to US$21, while for wood fuel it is around US$9. For instance, in South Africa, a 4 kg bag of firewood retails at about US$1.5 and 0.25 kg of coconut shell charcoal for US$3.5.

Briquettes need to be sold at similar prices to charcoal. Because charcoal is heavy and bulky, and has a low value by weight or volume, transport costs are a big cost component. There also tend to be many intermediaries involved. A producer may sell directly at the roadside, or to a trader who will take it to an urban area. Traders sell to retailers who sell to consumers. As a result of this chain, charcoal prices in cities are often double those in rural areas.

Price comparisons between countries are difficult because charcoal tends to be sold by volume (bag) rather than weight. The size of the bags can be different. Furthermore, the weight depends on the type of wood used and the degree of burning/carbonisation.

To provide some indication, the average charcoal price in Ghana was GHS1.2 (€0.14) per kg in 2020 – from GHS0.8 in Tamale to GHS1.6 in Accra. Current (2022) Burkina Faso rural mango area prices are €0.10 per kg, and prices in the capital may be double this. However, the sale price for a producer may be as low as €0.05 per kg.

In South Africa, charcoal and briquettes are much more expensive and are sold by weight, at roughly €0.70 per kg. In most value chains, retailers, wholesalers, and transport and logistics account for two thirds of the retail price. A producer will likely get about a third of the sales price. After retail and wholesale margins and transport costs are deducted, we can assume that the factory gate sales price for briquettes in South Africa is about €0.23 per kg. The difference in price is most likely the result of the fact that charcoal and briquettes are more often produced by formal companies who obtain wood in a legal way and must pay for it.

Based on the above, it seems obvious that competing with charcoal made from illegally harvested wood will be a challenge. Should government controls on illegally harvested wood for charcoal be better implemented, or if the wood supplies continue to decrease, we can expect that charcoal prices will increase. This could create more of an opportunity for mango briquettes, but that is not the case today.

2.3 Buying criteria

Most households and even companies use a basket of energy sources at any one time. This could be firewood, briquettes, hardwood charcoal, softwood charcoal or even gas and electricity. They then carefully select what they will use on each occasion, for their budget or even the availability of the energy source throughout the week or year.

Firewood, briquettes and other materials that allow for cooking and heating by open fire are all similar. As a result buyers have similar buying criteria when assessing the quality and benefits of briquettes. Most buyers first look for a material that is combustible. That means that it might burn easily, gives off a great deal of heat, can burn for a long time and creates very little smoke or bad smells. They also consider whether the material is easy or challenging to handle, transport and store.

2.3.1 Combustibility

The issue of combustibility is not as straightforward as it seems. Few materials have all of the qualities mentioned above. So, buyers need to make trade-offs when choosing what type of open fire fuel source to buy. This is also true when choosing the type of briquette, or even which supplier of briquettes to source from.

This is largely because the characteristics of combustibility that buyers prioritise change for different contexts. For example, Ghanaian street-food vendors might have a preference for soft wood charcoal that is easy to light and quick to reach temperature. They need to fire-up quickly if a client comes and they have no assistant on hand to tend to the fire while it gets to temperature. In households, this need for a fast fuel source is not as important. The fire can be lit early. In some homes children are given the responsibility of tending to the fire. A slower-burning hardwood charcoal, a dense briquette, or even firewood serves their needs just as well.

Even households might have very different preferences from day to day depending on what they are cooking. If someone is preparing a chicken, and they bought softwood charcoal for cooking they could be disappointed. It heats up quickly, but the heat is not long lasting. On this occasion they could choose harder briquettes or hardwood charcoal, which gives off heat that lasts for the 40 minutes to an hour needed to thoroughly cook the chicken.

These varying preferences make things challenging for mango briquette manufacturers. There are many options and no clear answers when it comes to how combustible a mango briquette should be. There is also not enough market experience to assess what people are willing to accept in terms of market price. The end use of the briquette and what their customers purchase matters. It is thus important that companies producing mango briquettes get a clear idea of the dominant uses of firewood, charcoal and briquettes. They should then decide on whether they should produce a dense, longer-burning briquette, a softer, more combustible one, or even a range of briquettes to cater for various customers and end uses. Further research and ideally a test market is needed to really give firm answers to this question.

2.3.2 Handling, logistics and storage

A quality briquette should be easy to handle. It should be hard enough (dense) so that it remains intact during transport and storage. This is called having low friability. The material also should not absorb lots of moisture from the air and should be at least partially resistant to light rain or small water spills. But, even here there are trade-offs that need to be made. If the briquette is too compact and too hard, it is not easily combustible. As a result it will not catch alight easily. But, if it is too soft it will break apart in handling.

The challenge in manufacturing briquettes is finding the sweet spot where the briquette is firm enough to withstand the rigours of manufacture, packing and transportation, but still loose enough to allow for good combustion. The sweet spot is not really clear. It is also affected by the degree of handling, transport, stacking and storage that is needed. Local sales in small bundles might allow for a softer, more friable briquette. But, if the briquette needs to be loaded onto a truck and transported to distant urban centres, the recipe will need to allow for a tougher, more resistant briquette.

This is very market dependant. Commercial mango briquette manufacturing is still relatively new and untested – especially at large scale. So, it is nearly impossible to paint a picture of exactly what recipe will create specific characteristics. This and what buyers will be willing to pay would need to be tested in the marketplace.

2.4 Market trends

2.4.1 Energy poverty

Many governments have been investing in expanding access to LPG, gas and electricity. In some countries, progress has been rapid (e.g. Tanzania). Nevertheless, for many less affluent households these sources of energy are not available, or are still too expensive to use all the time. Open fires then play an important role in keeping families warm, their homes lit and cooking their food. Even electrified homes, or those with access to LPG, might switch between different fuel sources, depending on the cost-effectiveness and convenience of doing so. Foods with shorter cooking times (e.g. frying eggs) might make gas sensible. Longer preparation times for meals such as beans might make firewood or briquettes more economical.[1]

2.4.2 Blended energy sources

Households and businesses in Africa tend to use a blend of energy sources, as electricity and other fuels are often too unreliable or expensive. In some countries, cheaper fuels such as firewood and briquettes are needed to fit in with lean budgets for energy. This is especially true in times of economic crisis, making the case for briquettes especially strong since the start of the COVID-19 pandemic and now during the Russia–Ukraine conflict.

1 Netshipise, L.F. and Semenya, K. (2022) 'Evaluating factors influencing firewood consumption in households at the Thulamela Local Municipality, South Africa'. Journal of Energy in Southern Africa, 33(2): 48–62. https://dx.doi.org/10.17159/2413-3051/2022/v33i2a9741

2.4.3 Deforestation

Increasing deforestation is making access to firewood more challenging for many rural households. Firewood, the most affordable household fuel, has several disadvantages. First, for those collecting it firewood is often difficult to find. Deforestation is a major challenge in most parts of Africa. Ghana, for example, is estimated to have the highest rate of deforestation globally. This forces mostly women to forage further and further away from home to find new sources of firewood.

2.4.4 Urbanisation

Urban residents have less access to firewood. Those looking for cheaper fuels can turn to briquettes. The trend towards urbanisation is still strong over most of the continent, which suggest that demand for affordable fuels such as briquettes is likely to increase.

2.4.5 Street vendors

Street vendors, many of whom sell grilled meats, fish or chicken, need briquettes for their businesses. Demand for meat is growing in most countries in Africa, which creates many opportunities for street vendors who sell foods. With growing urban populations, and an emerging middle class in some urban centres, there are opportunities for companies that are able to supply relatively clean, low-smoke, low-odour, cheap briquettes.

3. Supply

3.1 How do these products reach the market, what is the structure of the value chain?

Because it is so different from the business model of processed mango processors, and comes at a time in the year when they are most busy, briquette production is likely an activity best left to a separate investor. We can then assume that the briquette company would collect waste from factories, process it into briquettes and then sell the briquettes to wholesalers. These wholesalers or distributors would in turn sell to retailers, for example neighbourhood shops, market vendors or street vendors. This is a common structure for fuels and so we can expect that this would be a sensible approach for mango-waste briquettes.

It might also be possible for the processor to produce briquettes for a specific industrial buyer.

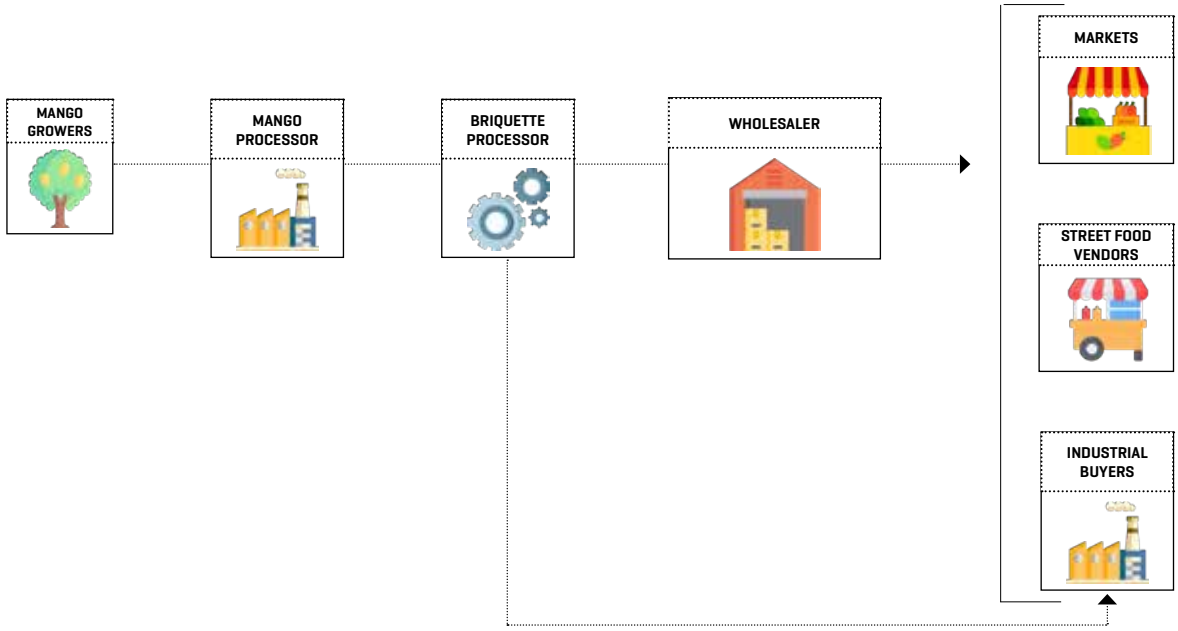

Figure 1. Overview of the briquette value chain

3.2 Seasonality

Mango-waste briquettes might not suffer from seasonality themselves: once well packaged and stored in a suitable place they can last for more than six months. Nevertheless, mango-waste briquettes rely on the mango season.

There are generally two mango seasons – a minor one and a major one. Mango processing happens during these seasons, making waste available then too. Outside of these harvest seasons, little waste is available, except from processors who source mangoes regionally, which have waste available for longer periods of the year.

Table 1 shows the major and minor seasons in a few African countries, i.e. when waste from local production is available. It is important to note that the length of the season might not reflect the volume of waste available; this is determined by the scale of production and the degree to which the ripe fruit is processed.

Table 1. Calendar of the mango season in various producing nations

	J	F	M	A	M	J	J	A	S	O	N	D
Senegal												
Burkina Faso												
Mali												
Côte d'Ivoire												
Ghana												
South Africa												
Kenya												

Major season
Minor season

3.3 Technology, processes and techniques

Briquettes are normally made with three ingredients – the main fuel source, a binding agent to hold the briquette together and a chemical additive that is sometimes added to enable the briquette to catch alight faster. Some examples of these ingredients are listed in Table 2.

Table 2. Example ingredients used in briquette production

Main fuel source	Binding agent	Chemical additives
▪ Coconut husk ▪ Mango peel ▪ Biochar ▪ Cashew nut shell ▪ Rice husk	**Optimal binders:** ▪ Cassava starch ▪ Rice starch ▪ Maize starch **Suboptimal binders** ▪ Acacia gum ▪ Molasses ▪ Cement ▪ Clay ▪ Tar	**Ignition agent:** ▪ Sodium nitrate ▪ Sawdust **Ash whitening agent** ▪ Borax ▪ Sodium nitrate

3.3.1 Binders

Materials with high lignin content are the most recommended as binders, because lignin is insoluble in water, is stable and can act as "glue" for the various ingredients in the briquette recipe. Lignin is also combustible.

Wood, potato, maize and wheat starch and flour are all rich in lignin, even if the vegetable sources tend to be less so. Some other binders can be considered, including clay, gum arabic and molasses.

The binder needs to be carefully selected as it can also be a source of smoke, unpleasant odour, and poor ignition and burning. In some settings this might not be tolerated by the buyer.

3.3.2 Production process

Figure 2. Typical biomass briquette processing stages

Stage 1: Reception of raw materials

In this step, mango waste is received at the factory. It is then sorted, and the pips are separated from the waste. The pips will become the base raw material for the briquettes. It is possible to blend other agricultural waste, or even biochar into the briquettes. In this case these raw materials are also received. Some raw materials need to be carbonised first – these are burnt to create a biochar. This is then ready for use in the final briquette recipe.2

Stage 2: Pip shell and kernel separation

To produce quality mango-waste briquettes, it is important to manage the water content in the product. The pip shell is thus removed from the kernel. Typically, this is done manually. This allows processors to remove the kernel, which can be used for oil production. The shell then needs to be dried. This can be done in the sun or using a drier – at least in theory. The mango harvest in much of Africa is in the wet season making sun-drying a challenging route for most companies. It also requires a lot of space and time.

Stage 3: Shredding and binding

In this stage, the mango raw material is shredded and the materials are mixed. The finer material is easier to bind. Water and a binder can be added at this point. For mango briquettes, binders may not be necessary due to the lignin in the pip shell. However, more testing is needed to determine whether the product can then withstand transportation and handling from the factory to the end market. This differs for each company and their customers. Binding may also be required when adding additional ingredients such as cashew or rice paddy husk.

Stage 4: Compacting

In this step, the raw material is ideally formed using a hot press method. The raw material is fed into a briquette biomass machine, which binds the materials further and forms the briquette. Cashew briquettes, which are better known, tend to be about 5.5 cm in diameter and 10 cm long. This would be a good benchmark for the size and shape of mango-waste briquettes.

Some trials have tested cold compression. This uses a screw press and pressure to form the briquette. However, this might not be suited to mango-waste briquettes, especially if no binder is used in the formulation.

Stage 5: Drying of briquettes

The briquettes are then left in the sun to dry. Some companies might use specialist drying machines, but this then increases the cost of the briquettes.

2 Sawadogo, M., Tchini, S., Tanoh, S. et al. (2018) 'Cleaner production in Burkina Faso: case study of fuel briquettes made from cashew industry waste'. Journal of Cleaner Production, 195: 1047–1056. https://doi.org/10.1016/j.jclepro.2018.05.261

3.4 Equipment

Producing mango briquettes requires a lot of equipment:

- Mango pip shell cutter, to split open the pip and remove the inner kernel
- Chipper to grind the mango pips and blend with other ingredients
- A blender may be needed
- Briquette biomass machines to heat the pulp and press it into briquettes.

Economic viability

Looking at what needs to be done to produce briquettes with mango waste, it is obvious why there is currently no commercial-scale production – it is too complex and expensive. Plus the yields and thus volumes will be too low. So, there is a real question of whether drying of pips and the final briquette is possible in the harvest season.

First, the only part of the mango that can be used is the pip, and this is difficult to separate from the rest of the mango. Mango juice factories put skins and pips together. Drying factories can separate pips from peels, but are not always interested in this added complexity. Furthermore, the pips will still contain some mango flesh, which may affect the product and may need to be removed. Finally, rotten mangoes that are largely intact are also an important waste stream that can probably not be used for briquettes unless a machine is added to take out the pip. For all this, either a lot of manual labour is needed or machines need to be developed and purchased, which will add to the production cost.

The second issue is that the pip has an outer shell and an inner kernel. The shell is hard, fibrous and contains lignin. The inner kernel, however, contains a lot of water and is difficult to use. The complete mango kernel still has 44% moisture content. There are two strategies here.

1. The whole pip is shredded and then may need to be dried before briquetting.
2. The outer shell is separated with special machinery, and then shredded.

The first option will increase the water content, which may lead to a longer drying time after pressing, or may require drying even before pressing. On the other hand, some water is needed in the compacting process, so it may not make a difference. The oil content of the inner pip may also lead to additional smoke and smells.

The third issue is the low yield. Depending on the variety and the size of the fruit, about 50–60% of the fruit is flesh and 20–25% of the weight is pip, while the rest are peels. This pip has about 45% water. This means that a completely dried pip is only 12% of the weight of a mango. If only the outer layer of the pip is used, this may halve. So one tonne of mango will only yield about 60–120 kg of briquette. A mango typically weighs about 600–700 grams, which means that 1,538 mangoes make a tonne. Thus, about 1,500 mangoes would be needed to produce around 100 kg of briquettes. This is a lot of work to produce a small amount of briquettes.

The fourth issue is the drying that is necessary after production. Mechanical drying will almost certainly make the product too expensive. Sun drying on the other hand is difficult because a large part of the mango season coincides with the rainy season. Furthermore, it would require a lot of land and labour to spread out the briquettes for drying.

In conclusion, to be able to produce 100 kg of briquettes a company would need to:
1. separate pips from peels and mango flesh for 1,500 mangoes
2. potentially remove fruit residues from the pips
3. possibly remove the inner kernel, shred the pip
4. potentially purchase and add a binder and blend this in
5. spend energy on heating and pressing the briquettes
6. dry the product during the rainy season
7. collect the briquettes, weigh and bag them.

After all this, we would get about 100 kg of briquettes, which typically would sell for about €0.10 per kg. The total revenue would then be €10 for a wage of 1,500 CFA (€2.30). Even with the low wages in Africa this revenue only allows for wages for two people for a day. We must ask whether this activity is viable at all.

4. Ingredients for success

4.1 Not economically viable

Briquette production from mango pips is not likely to be economically feasible anywhere (see Box), but certainly not in most of Africa where charcoal made of illegally harvested wood is available and cheap. The amount of work needed to produce briquettes from pips simply makes the product too expensive.

The only chance for success is in formal economies where charcoal prices are high, but these do not tend to be mango producing countries. However, those countries tend to have an abundance of waste from processing that would be far easier to transform into briquettes than mango pips.

4.2 Issues and opportunities summary

Table 5. Issues and opportunities

Opportunities	Issues
▪ Demand for cheap energy from households and industry. ▪ Open fires remain an important part of the energy mix for households and street food vendors. ▪ Availability of raw materials, some of which are free or very low cost. ▪ Space for different types of mango briquettes – soft, hard, long burning and easy to fire up.	▪ The process is not simple and it requires a company to make many choices about the recipe based on relatively little available market information. ▪ Mango briquette production is largely untested commercially, which raises many challenges for a company. ▪ The complexity means that mango processing companies are unlikely to themselves take up this activity, especially as it requires production in the mango processing season. ▪ Companies will need to invest in technology despite low revenues. ▪ This is a challenging business model on all levels, including whether it is financially sensible to invest.

9 | MANGO COMPOST

This chapter has been developed by the Fit For Market + and Fit For Market SPS programmes, implemented by COLEAD within the framework of the Development Cooperation between the Organisation of African, Caribbean and Pacific States (OACPS) and the European Union (EU).

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Contents

1. What is mango waste compost?

Compost is a material made from decomposed plant material and in some cases animal manure that is used to enrich soil. Many ingredients can be used. However, waste from mango processing creates opportunities for this to be used as an ingredient. Compost using mango waste typically includes discarded fruit from sorting, and flesh, peels and pips from the cleaning process. This is then all owed to decompose and can then be packed or distributed to farmers.

Figure 1. A generic composting process

Compost can be used alongside mineral fertiliser, or even as a partial replacement for it. When the quality is good and it is used sensibly, it enriches the soil. This allows for better yields or improved quality of produce. Mineral fertiliser and compost are made differently and perform slightly different roles in improving the soil. These are summarised in Table 1.

Table 1. Differences between mineral fertiliser and compost

	Mineral fertiliser	Compost
What it is made from	NPK is made from minerals that are mined, and chemically changed.	Compost is made from plant material and sometimes manure.
What it does	NPK gives a quick, short boost of nutrients for plants. But a lot is lost when it rains, through run-off or leaching. It needs to be applied every year. NPK will not improve the soil structure.	Quality, nutrient-rich compost is slow release: it releases nutrients gradually, and sometimes binds ingredients. This helps it to improve the soil structure and the carbon content.
How it is applied	50–400 kg per ha. Or 2 kg per tree. 1 work-day/ha. Different application techniques can be used such as broadcasting, banding, deep soil placement, in irrigation, foliar sprays.	5–10 tonnes per ha or one wheelbarrow per tree. 5–10 work-days per ha. Can be used as a mulch, thin top dressing and blended with soil.
Different blends and dosages	In developed countries, each crop has specific N-P-K blends. Dosage (application rate) should be adapted to the crop and crop stage, soil type, etc. Farmers and companies should be advised to apply using the "4Rs" strategy – apply from the right source, at the right rate, at the right time, and in the right place.	Compost varies depending on the material used to make it. A wide variety of green and brown matter, animal droppings, etc., can be used in the recipes. The recipes can be adapted for specific crops. But this is seldom the case. Instead, most buyers adapt the dosage when applying compost depending on the condition of the soil. Biochar and bio-stimulants can be added to improve the quality and nutrient uptake.

2. Demand

Organic materials in the soils of tropical countries tend to break down very quickly. As the organic matter declines, soils can become depleted of nutrients. Compost and fertiliser are thus valuable additions to enrich the soil and improve soil health.

When the right amounts of compost and fertiliser are added to meet the nutrient needs of various crops there can be marked benefits to soil health. This in turn can increase yields and improve livelihoods for farmers. Soil fertility is thus increasingly a focus of farmers, governments, development organisations, non-governmental organisations (NGOs), buyers of produce from the developing world, and importers in Europe and USA. This creates opportunities for commercial producers of compost and fertiliser.

There are some important differences in the market for mineral fertiliser and compost. First, safety and phytosanitary controls mean that compost cannot easily be moved across borders. It is heavily regulated and in many cases cannot be imported or exported easily or even legally. International trade of compost is thus costly and difficult.

Second, mineral fertiliser is concentrated, especially when compared with compost. For example, a 1 ha farm might require 150 kg of NPK fertiliser, whereas 5–10 tonnes of compost is needed on that same hectare simply for maintaining the soil health. The transport costs to supply a 1 ha farm with compost are thus much higher than those of fertiliser. The added transport costs can make compost unaffordable for many small-scale farmers.

These key differences mean that mineral fertilisers tend to be traded internationally and their market is large. More than €90 billion of mineral fertiliser was traded globally in 2021.[1] In contrast compost is typically manufactured and marketed locally.

The actual scale of demand in individual markets is difficult to assess, especially for mango waste compost. In this particular case, it is more likely that the bottleneck will be supply and access to finance rather than demand. Supply is limited by the volume of mango waste available each season and whether farmers can access the funds to pay for compost. The affordability is explored in section 2.2.

2.1.1 Small-scale organic farmers

Compost is an important ingredient in organic farming. Organic farmers cannot use synthetic or mineral fertilisers such as NPK. In many cases, small-scale farmers use nothing at all to enrich the soil, which in the longer term causes steady declines in yields and soil degradation. This has created significant yield gaps between farmers in sub-Saharan Africa and those on other continents.

In some countries, there are thousands of organic farmers – often by default. In Burkina Faso alone there is an estimated 20,000 ha of organic mango orchards, and another 5,000 ha of organic cashew orchards. If compost could be made affordably and financing could be secured, then these farmers would need at least 125,000 tonnes of compost per year. In Burkina Faso there are also other important organic crops such as sesame, fonio and hibiscus, each creating a potential market for compost.

1 ITC Trade Map.

The size of the market would thus depend on the area being used to grow organic crops in each country. Naturally, not all farmers will invest in compost, so this would have to be considered when estimating the size of the market.

2.1.2 Vegetable farmers

Vegetable farmers tend to produce a lot of vegetables on a small area of land. Vegetables also tend to be high-value products. This creates space for the farmers to pay for compost. They know that compost is essential for vegetable farming. This is especially true of those farmers who grow vegetables that absorb and require lots of nutrients when growing (e.g. ginger, maize, cabbage, tomato, beets).

As a result, these vegetable farmers tend to use compost which helps the soil better retain moisture and nutrients. This is very important in vegetable farming. They also tend to follow an annual calendar, growing different vegetables throughout the year. This is advantageous to compost producers as their clients need compost throughout the year.

2.1.3 Spice farmers

Spices are increasingly in demand across Africa. This is especially true for ginger and bird's eye chilli for which producers are unable to keep up with supply. Prices are thus often high, or produce is shipped across borders.

Production of these spices is generally hampered by poor soils. The plants tend to be relatively small and yields are low. Adding fertiliser and compost would thus be beneficial.

These are quite lucrative crops. So in many cases farmers can afford to buy compost.

2.1.4 Outgrower programmes

Farmers in outgrowers programmes tend to get access to finance for inputs. The outgrower programmes can also help to coordinate sales, to manage logistics and to secure access to finance. This is very useful when you consider that compost requires a substantial cash investment.

Rice outgrower programmes in Nigeria, for example, buy in fertiliser to distribute to farmers in their growing system. The same is true of vegetable growers in Kenya, Senegal and elsewhere. Using Nigeria as an example, one of the main producers of rice in Africa, if not the largest, uses an average of 244.35 kg of fertiliser per hectare per year. Rice is grown on around 1.7 million hectares per year in Nigeria.

Tobacco, fruits, vegetables, onion, potato, spices and macadamia are some further examples of crops grown in outgrower programmes in Africa. But there are likely many more. These offer possible marketing opportunities for composting companies.

2.1.5 Nurseries

Seedlings are vulnerable. Most nurseries go to some length to protect plants in this vulnerable early stage of life. This might involve growing the plants under shade cloth or in greenhouses, using sprinkler systems, and wherever possible preventing contamination. As a result, most nurseries avoid adding unnecessary chemicals. To enrich soils, they prefer using natural products such as coca peat (coir) or compost from agricultural waste.

This has an added benefit as the seedling can be sold to buyers involved in both conventional and organic farming. Most nurseries cover a small area. A nursery the size of a standard tennis court (260 m2) can produce thousands of plants. So, applying compost is a practical choice.

2.2 Relative pricing

There are two general types of compost on the market in most African countries (Table 2).

Table 2. Price comparison (retail pricing) of simple and enriched composts (Burkina Faso, September 2022)

	Simple compost	Enriched compost
Ingredients	Usually made with plant materials only. Using nutrient-rich base materials can help to add additional potassium and phosphate, which are sometimes not sufficient in simple compost	Made with additional ingredients to increase N-P-K value: manure from cows, chickens; added phosphate, etc.
Price	€115-–153 per tonne (delivered on field)	€153–230 per tonne
Volume per ha	5 tonnes	4 tonnes
Total cost per ha	€575–765	€612–920

Compost is sold per bag or per tonne.

- Per bag of 50 kg (as NPK fertiliser): This requires sieving out big pieces, weighing and bagging. It also increases the cost of production and affects the profitability of the business. This is more suitable for small, private buyers (e.g. consumers). Small nurseries might be interested in retailing these smaller pack sizes. Bags have the benefit that the buyer is responsible for transportation.
- Per load: In this method, the compost is sold by volume (m^3) not by weight. This is simpler, cheaper and could be more suitable for farmers. In comparison, if you apply the minimum volume of 5 tonnes per ha, you would need 100 bags of fertiliser. This is not very practical, and it also could be more expensive as packaging and packing costs need to be included in the sales price, hence the per-load preference for large surface areas.

2.1.1 Competitive analysis

Compost and fertiliser have different roles in improving soil health and fertility. As most farmers have real limitations on the funds they have available for improving their soils, they have to choose whether they can afford either or both at once.

Mineral fertiliser is thus the biggest competitor – even when buyers have sufficient funds available.

What then is the value equation faced by the farmer? A mineral fertiliser is expensive per kilogram of product. For example, in Burkina Faso, NPK fertiliser could be 5–7 times more expensive than enriched compost. However, fertiliser is more affordable than compost when you compare the total cost of applying the product on a hectare of farmland: a farmer on a single hectare of land might apply 150 kg of fertiliser. Even at a relatively high purchase price

of €1,000 per tonne, the farmer would need only €150 to purchase the fertiliser. In contrast a hectare of land requires 5 tonnes of regular compost or 4 tonnes of enriched compost. In Burkina Faso, even at the lowest prices for simple compost the farmer would need to spend €575 for the smallest volume of compost needed on the hectare. This is nearly four times the total cost they would need to spend on fertiliser for the same area of land.

Table 3. Comparison of total cost per hectare compost versus mineral fertiliser (Burkina Faso, September 2022)

	Simple compost	Enriched compost	NPK
Price (Burkina Faso)	€115–153 per tonne (delivered on field)	€153 and €230 per tonne	€763–1,000 per tonne
Amount per ha	5 tonnes	4 tonnes	150 kg
Total cost per ha	€575–765	€612–920	€114.50–150

Applying 5 tonnes of compost might also require the farmer to hire staff, or to hire machinery. These both come at additional cost.

In general, many farmers will not have sufficient funds available to make the full investment. So, many apply whatever they can afford. They also make trade-offs, blending compost and NPK. Cash-strapped farmers might apply only NPK.

Compost can benefit all farmers. Yet, it is more likely to be bought by farmers with specific characteristics.

1. High-value niches: These farmers grow produce that generates more cash even with smaller volumes of produce. Ginger, mangoes, avocados, potatoes, passion fruit and seed multipliers are some examples.
2. Intensive cultivation: Farmers who farm small parcels of land can afford to buy and handle compost. The total labour and transport costs are lower and it is simpler to move, store and apply. Vegetables, seedlings, strawberries and blueberries are some examples.
3. Quality-oriented markets: These sectors value produce that is a very high quality. Traceability and certification are often important, especially where these products are finally bought by shoppers for health and wellness reasons. In many cases the products are certified, e.g. organic. Hibiscus, herbs and spices, export-oriented vegetables such a green beans, radish and baby corn are some examples.
4. Outgrower or similar arrangements: In outgrower schemes, the farmers have a reliable buyer, which makes investing sensible. The outgrower might insist on compost being applied to improve quality and yields and to justify any investments they are making in the farmers' production. In some cases, the outgrower might themselves pre-finance or purchase compost on behalf of the farmers in the programme. Rice, vegetables, tobacco, tea, potatoes, macadamia and even mango are some examples of produce sometimes grown in outgrower programmes. However, pre-financing can come from processing companies, exporters, storage companies, etc.
5. Pre-financed crops: Farmers sometimes get pre-financing from traders. This might give them access to finance that is needed to invest in compost.

For smaller plots of land it might be affordable to pay labourers to apply compost manually. However, access to mechanisation can make compost application more practical and feel less challenging.

2.3 Buying criteria

2.3.1 Enriched or not

As a minimum, compost should improve the structure of the soil. In some cases, the compost mix can be enriched. Typically, compost is enriched with waste such as poultry droppings. However, it is possible to add mineral fertiliser. Adding mineral fertiliser such as NPK might disqualify the compost from being used in organic production.

Compost also adds micronutrients such as magnesium, zinc and selenium that are not always available in mineral fertilisers.

2.3.2 Well matured

Quality compost is carefully produced so that all the plant and animal waste is decomposed. It should be free of large pieces of plant material. A well-matured product looks like a humus. It is black in colour and has a neutral smell. Ideally, it should smell like humus too.

2.3.3 Carbon–nitrogen balance

Compost adds both carbon and nitrogen to the soil. As a minimum, the compost should have a good balance of carbon to nitrogen. In general, a well-balanced compost has a ratio of 15:1 up to 20:1 of carbon to nitrogen. Too much carbon means that the compost will reduce the available nitrogen in the soil, and fewer nutrients available for the plant. If the compost has too little carbon, then the compost is not stable, it can lose nutrients quickly after rains and does not improve the soil structure sufficiently.

Sources of carbon are generally brown matter waste such as stalks, cereals, hay, straw, wood chips and sawdust. Coffee grounds, manure, corn husks and other green matter waste (vegetable and fruit scraps) provide nitrogen.

Phosphorous, sodium, potassium and other nutrients can all be added to the soil from compost. The availability of these nutrients is stongly dependent on which ingredients are being used in the recipe. A compost that is enriched with manure tends to improve the balance of carbon and potassium and phosphorous.

Adding ingredients increases the cost of compost. So, each compost producer will need to decide whether adding these ingredients benefits the farmer, their customer and their business. In the end it might make for a better compost, but it could harm profits and business sustainability.

2.3.4 Acidity

The pH of the final compost is important for soil health. Most African soils are generally acidic. The ideal pH for crops is between 7 and 9. Compost provides some temporary changes to the pH of the soil, which can be enough to allow for a seasonal crop.

Mango-based compost, which is wet, tends to ferment and become acidic if the ingredients are not balanced. It also needs disciplined turning to keep the pile decomposing rather than fermenting.

2.3.5 Contaminant free

A good compost should not introduce unwanted seeds of weeds or potential diseases. It should also not have heavy metals, large pesticide residues, plastic, glass, etc. These need to be managed carefully when selecting the ingredients and then during the composting process. It is especially important that the compost reaches temperatures of between 60°C and 70°C, which is too warm for bacteria and seeds to survive. This is called hygienisation. It is a crucial step for ensuring that the compost meets safety and phytosanitary standards – even where this is not required by legislation.

2.4 Market trends

2.4.1 Outgrower programmes requiring inputs

Outgrower programmes are growing as some supply chains become more commercial. Processing companies and exporters are seeing the benefits of developing an ecosystem of suppliers who they train and who then supply the company with reliable quality produce. This has been a crucial development in supply chains such as counter-seasonal vegetables for export in Kenya, Senegal, Morocco and Egypt; or local market rice in Nigeria, Tanzania and Ghana.

As experience in these chains grows and more companies learn how best to develop successful outgrower programmes, we expect increasing interest in inputs such as compost.

Organic food

Demand for organic foods has been maturing in developed markets. This creates opportunities for African farmers. But it also requires strict control of the chemicals being used to grow certified products. Compost can be a solution for many farmers provided that suppliers of compost pay attention to the ingredients included in their compost recipes.

Ingredients such as cotton, or even cocoa, which use lots of pesticides, are not suitable ingredients for compost. The compost should ideally be enriched to counterbalance the removal of nutrients from the soil.

Sustainability for exports

Compost returns nutrients to the soil and improves the soil structure. This is crucial for long-term soil health and for yields that can be achieved on this land. It is important to be aware that a compost can help, but it might not always be sufficient to restore the soils.

Awareness is growing around the issue of soil fertility and the harmful effects on farmer livelihoods. Responsible buyers in developed markets increasingly value sustainability stories. This does not always translate into higher prices. But, it can be a benefit when marketing your product.

3. Supply

3.1 How do these products reach the market, what is the structure of the value chain?

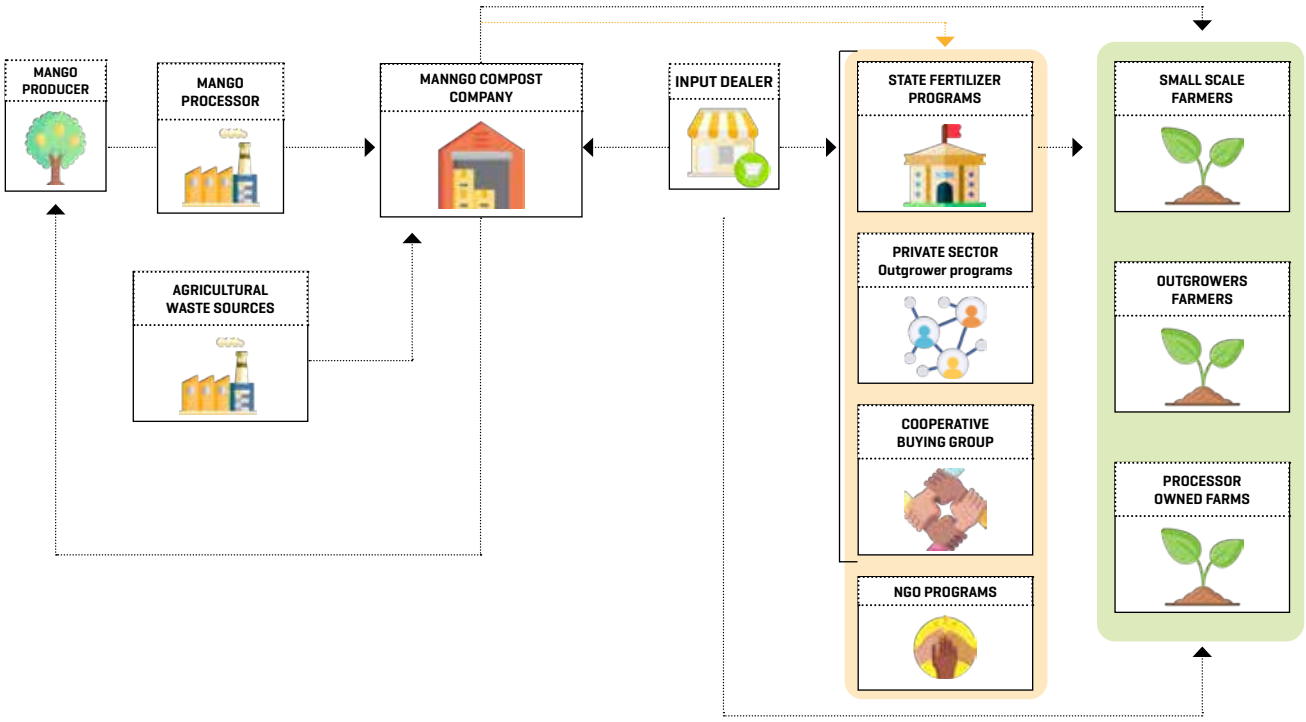

Figure 2. Overview of the compost and fertiliser value chain

3.2 Sources of ingredients

Agriculture produces a fair deal of waste. In some cases agricultural wastes are used in animal feed recipes, e.g. rice straw, maize stalks. However, in the case of mango waste, mango processors need to somehow dispose of the growing mountain of pips, peels, flesh and rejected mangoes. The waste creates unpleasant odours for local communities. And in many cases processors pay for the waste to be removed and dumped further away.

Waste from poultry, another growing industry in Africa, is also dumped or sold off to buyers. This is a rich source of nutrients that can enrich compost recipes.

3.3 Intermediate distributors

Compost can be sold directly to farmers. However, there are a number of actors who play a role in distributing inputs, for example input dealers, state programmes, private sector outgrower programmes, cooperative buying groups and NGO programmes.

3.3.1 Input dealers

Most African farmers own less than 1 hectare of land. As a result, they prefer to obtain compost from the nearest input supplier, which can facilitate the purchase of small quantities and save on transport costs. Input dealers are often in urban centres, but there are examples of stores in larger rural centres. Sometimes input dealers are linked to state programmes. They make use of the distributions points in these state-funded input programmes and so can provide closer contact with farmers.

Selling compost to input dealers in urban centres has cost implications that compost manufacturers would need to take in to consideration. Moving compost long distances can be expensive as it needs to be supplied in large quantities.

3.3.2 State input programmes

In some countries agricultural inputs such as fertiliser are subsidised and made available to small-scale farmers. Classically, state programmes source fertiliser from input dealers, who themselves import seed, fertiliser, pesticides, etc. State programmes tend to offer cheaper inputs, but farmers do not always benefit. The programmes are often troubled with distribution issues, poor governance, gaps in distribution and unreliable management. As a result quality control on the inputs can be poor.

Locally made compost has the potential to address some of these issues, especially if it is a quality product that is available close to farmers, from a reliable supplier. At present, this is not an established route to market for compost producers. But it could be a lucrative contract if this does become a priority for government sourcing.

3.3.3 Outgrower programmes

Outgrower programmes are increasingly being used to create a more predictable, stable supply chain. In these systems, processors, mills, off-taker (buyer) farmers, packhouses, etc., coordinate farmers, provide training, and sometimes pre-finance and supply key inputs. Fertiliser is often included in the inputs supplied and distributed in outgrower programmes.

Rice, vegetables, mango, potato and onion are just some examples of value chains where outgrower programmes are being created and managed across Africa.

3.3.4 Cooperative buying groups

Compost can also be purchased by farmer cooperatives. The farmers work together to source inputs. By working together they can negotiate better pricing, logistics, etc. This is a potential customer for compost companies – especially as it can help to coordinate deliveries.

3.4 Technology, processes and techniques

3.4.1 Production process

There are many compost techniques. However, these techniques can largely be divided into aerobic (with oxygen) and anaerobic (without oxygen).

To prepare for anaerobic composting, the waste ingredients need to compacted in pits and covered with plastic. They can also be composted in closed chambers or vats. There are advantages to anaerobic composting. For example, the process produces a liquid that can be sold as a valuable foliar fertiliser. However, anaerobic techniques might not be suitable for mango waste compost. Mango tends to ferment and become acidic. The process is also technically more difficult and it requires greater investment than the alternative, aerobic techniques. If you intend to produce 10 tonnes of compost, it requires the company to dig a large number of pits, or invest in many vats. This process also takes longer and stinks. In countries where land is limited this might not be practical.

Aerobic compost in comparison is far simpler. You mix the waste ingredients in a pile and turn it regularly. The investment costs are lower and you can easily scale up production to produce larger volumes of compost. If you prepare ingredients well, ensuring that the particles are broken down into smaller pieces, the process is quick (50–60 days). Most importantly, this technique is better suited to mango waste, as long as a good technique is used and the pile is turned enough.

The production process for an aerobic composting technique is described in Figure 3.

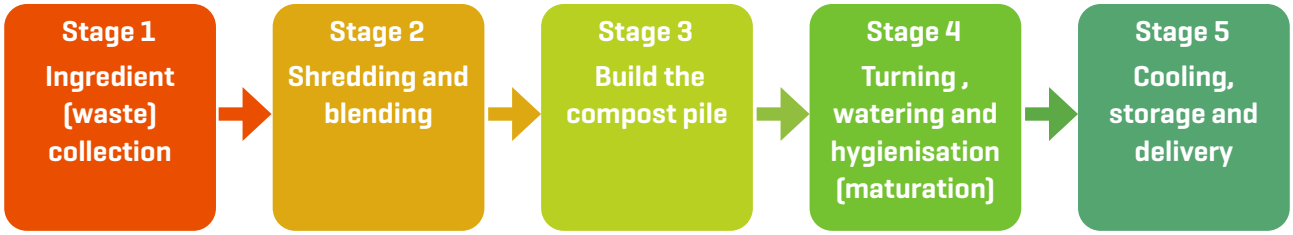

Figure 3. Production process for mango waste compost – aerobic technique

Stage 1: Ingredient (waste) collection

Mix the green and brown materials together. A good recipe will include particles of different sizes, textures and structure. So, it is important to gather ingredients of various sizes and that have the right balance of nutrients. The ingredients that are available during the mango season will determine what is possible for the final compost recipe.

Stage 2: Shredding and blending

The brown and green materials need to be blended so they can interact with each other. The smaller the size of the pieces, the quicker the composting (more surface area). The larger the pieces the less likely that compost can be prepared in 50–60 days.

The ideal situation is to select ingredients that have different shapes and sizes. If the ingredients are selected to be different materials the different rates of breakdown of will result in a blend that is not the same throughout.

The mango waste ingredients need to be prepared well. Mango pips need to be shredded, otherwise they will not decompose properly, or quickly enough. Whole overripe or infected mangoes need to be shredded to speed up their decomposition. Shredding peels will make them smaller and will also allow them to break down faster, but is not essential.

During shredding, mango peels and pips should not be mixed together. When they are, they form a pulp that might clog up the shredder. This is something to watch out for. Ideally, keep them separated.

It is also important to accommodate the fact that mango tends to be wet. The moisture from the mango binds to the brown matter, which is a good thing. But, if the dry matter is too floury the blend creates a porridge-like sludge, which stops oxygen flowing through the pile. The mix then ferments rather than decomposes. Some examples of ingredients that tend to form a sludge when blended with mango are fine rice husks, sawdust and other finely ground or shredded materials. It is best to avoid these ingredients when blending mango waste compost. Dry matter that works well in the mango compost recipe is fibrous and resistant to forming a sludge – for example, straw, maize stalks, cotton stalks, cashew shells, sorghum stalks.

Table 4. Materials to combine with mango compost for a good blend

Material	Shredding instructions
Rice husk	Already small; does not need to be shredded
Cashew shell	Very hard and needs to be shredded into small pieces
Rice straw	Should preferably be shredded to make mixing easier, but not essential because it is thin
Maize and sorghum stalks	Need shredding
Leaves and branches	Waste from pruning that is < 10 cm diameter can be included – needs to be shredded and chipped

Stage 3: Build the compost pile

For large-scale compost production in rural areas, it is best to use the windrow method. In this method, long rows of compost are made in a pile above ground. Some companies compost under a roof, because it protects the pile from the sun (too much heat) and rain (too much water). But this is not necessary.

If you do not have a roof, you may need to water more often during hot sunny weather, and cover with plastic during rain. But this is probably cheaper than building a roof.

Size of the piles

Small piles allow more oxygen in, but they also lose heat, which is needed to break down the material. On the other hand, large piles become too dense and may not allow enough oxygen in. In practice, the minimum size of a pile is 1 m^3. A good size for piles seems to from 2–4 metres high and 3–6 metres long.

When selecting the size of the pile, it helps to consider the type of material being used in the recipe. If material is very heavy, dense and wet, then the pile should be smaller. If dry and airy, then it can be larger.

Whether you turn the pile by hand also matters. A large pile is difficult to turn by hand. If turning by hand is the only option, it might be best to stick to a maximum of 2 m high and 3 m wide. But even this requires some experimentation to learn what suits the company's situation best.

Figure 4. Compost rows under cover in a commercial compost factory

Make a new pile every 2 days

Ideally, a company will make a new pile each day or every second day. It is important to add all the ingredients at one time, so that the top and bottom of the pile are at some stages in the process. Adding new material also brings the temperature down and prevents the pile from moving to the next stage of maturation.

Stage 4: Turning, watering and hygienisation

As a rule, compost should be mixed every 15 days. This is called turning. If you turn it too often, heat will not build up in the pile. You will also disturb the micro-organisms (bacteria, fungi) in the pile, and these are essential to a healthy, quality compost. On the other hand, if you turn the pile too little, there will not be enough oxygen, and the pile will start to ferment.

How often you need to turn the pile depends on several factors such as the material you use, the blend and the outside temperature. It is therefore important to regularly check for signs of whether the heap needs to be turned. Typically, this is before the bottom begins to ferment. However, being able to estimate the right time for turning is learnt from experience and from testing the pile.

When turning the pile, it helps to be quite thorough. When you turn it, the inside should be brought to the outside and vice versa. The most efficient way of turning by hand is to move the entire pile to the next row.

Managing the moisture content of the pile is crucial. When you turn the pile, you should check the moisture levels. It is possible to manually check the moisture content. This can be done be holding a sample of the composting material in your hand and assessing whether it is too wet, or dry. This is illustrated below.

If water leaks out in a thin stream, it is too wet		*Add brown matter*
If a few drops fall between your fingers and the compost stays together when you open your hand, it has good moisture content		*No action*
If the package comes apart and nothing drips out, it is too dry		*Add water*

Managing the moisture content is so important that a more accurate measurement might be preferable. This can be taken with the help of a small, portable probe. If the moisture level is below 60%, you wil need to water it.

The best moment for watering the pile is when it is being turned. This ensures that the piles are wet throughout, which is not always the case when you water a pile from the top.

Hygienisation

A critical point in compost production is hygienisation. This ensures that bacteria, seeds and other unwanted organisms, naturally present in rotting fruits, vegetables, crop residues and even in manure, are made harmless.

The first step is, of course, sourcing ingredients that have relatively few contaminants. Then preparing the pile to ensure that the ingredients reach at least 55°C during the first few weeks. This heats the pile enough to stimulate enzymes and kick-start the growth of organisms that will be needed to break down the organic matter.
In the second phase, heating, the temperature rises first from 55°C to about 65°C. This

increase in temperature plays a critical role in hygienisation. Pathogens, weeds and other unwanted organisms are unable to survive, enabling the final compost mixture to be safe for application on farmland. If the temperature in the pile remains too low, then pathogens will remain in the compost. If the temperature rises above 65°C, then the organisms whose role is to break down the organic matter cannot survive their time in the pile, so the compost structure and nutrient value will not be as good as hoped for.

If careful attention is paid to shredding and blending the materials then each pile will go through four phases of maturation which together last 50–60 days:

1. Starter phase (about 2–5 days)
2. Heating phase (days 5–25)
3. Cooling down phase (days 25–35)
4. Maturation phase (about days 35–50)

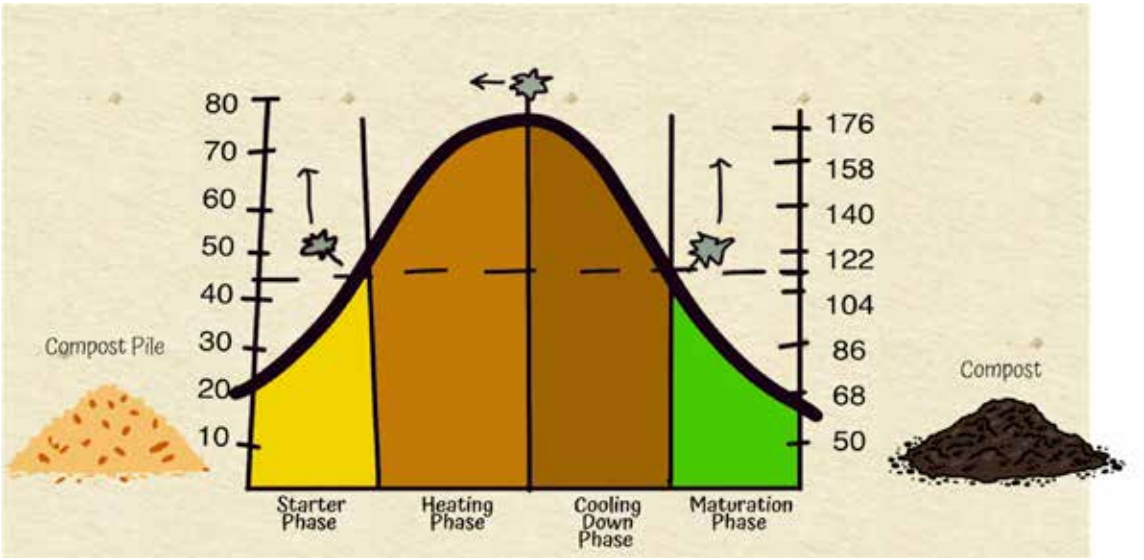

Figure 5. Production process for mango compost waste

Cooling, storage and delivery

Ideally the compost will be ready in about 60 days.[2] It will now need to cool down and be readied for sale or application. First, the pile must be opened. This enables the technician to check the level of decomposition and whether the pile is fully matured. A well-matured pile will be cooling, the smell will be neutral or be like the smell of a forest floor, the material will have broken down, and the texture will be even throughout.

As the compost is now ready, it can be sold and distributed to farms. Some compost companies distribute the compost on the back of trucks or tricycles. However, input dealers might prefer that the compost is packed into bags of various sizes. If a buyer has not been found, or they are not ready for delivery, the compost can be stored in a cool, well-shaded place that is protected from rain and sun.

2 Cooperbrand, L. (2002) The art and science of composting: A resource for farmers and compost producers. University of Wisconsin-Madison and Center for Integrated Agricultural Systems.

3.4.2 Mango waste recipes

There are in reality a wide range of recipes for mango waste. Each compost manufacturer will need to develop their own recipe based on whatever material is available locally. Whatever materials are selected it is important that the final recipe balances the amount of carbon and nitrogen that is released into the final compost. This requires a good balance of mango waste, which contains nitrogen, and other ingredients that contribute carbon. The ideal carbon to nitrogen ratio is 25:1 to 30:1.

Mango waste can consist of peels, pips and entire mangoes that are rotten. Each component has a different carbon and nitrogen content. This means that they each have a different C:N ratio. The more mango flesh and peels are included the higher the nitrogen content. As pips are higher in fibre, which is a good source of carbon, including more pips in the recipe increases the C:N ratio of the final compost.

Table 5. Selected nutrients and carbon : nitrogen content in mango waste

	Carbon % (C)	Nitrogen % (N)	C:N ratio	Phosphorous pentoxide (P_2O_5)	CaO
Mango waste with pip	22%	0.63%	35	0.15%	0.27%
Mango waste without pip	21%	0.78%	40	0.18%	0.27%

Source: Nutrient content from www.feedapedia.com

This can be achieved by blending to together mango waste (rich in nitrogen) and brown matter such as straw, maize stalks, cotton stalks, unshredded cashew shells, branches, moringa, sorghum stalks. It is important to select brown matter that is available during the mango composting season.

Manure can be added to enrich the compost recipe. It ensures that the mango waste compost has sufficient nitrogen in the recipe.

Table 6. Recipe with costs (Burkina Faso, September 2022)

Ingredient	Proportion	Unit cost (CFA per tonne)	Total cost (CFA)	Role in the recipe
Mango waste (a blend of pips, flesh and peel)	40%	0	0	Adds nitrogen
Rice husks	40%	0	0	Good source of carbon, and creates structure in the compost
Bedding (rice husks + chicken droppings)	20%	10,000	2,000	Enriches the compost
Total			2,000	

Customising the recipe to your context

The trickiest part of developing the recipe will be in assessing whether the ingredients available together achieve the right balance of carbon and nitrogen. This requires some research. Good sources of this information are in the feed sector. Feedapedia is an excellent

resource for assessing the carbon and nitrogen content of different ingredients that are also used in animal feed. Local research institutions and feed experts can also be consulted. This information will allow you to adapt the recipe to what is available and makes sense from the perspective of costs.

3.5 Technology

The technology for producing compost commercially is relatively simple and inexpensive (see Figure 6). Equipment is needed for thorough shredding. Diesel-powered equipment is important. The shredder should be at least 15 horsepower. It should also have a large aperture to make it easier and faster to use. This is especially important as most compost makers are likely to include branches and twigs from prunings in their recipes at some stage during the year. It should also be portable and should allow for regular cleaning and sharpening of the knives.

Simple, small, portable measurement probes are also helpful. They allow accurate temperature measurements to be taken so that the technicians can assess whether the pile is decomposing, when it is maturing and when it needs watering.

Turning equipment can be as simple as shovels and forks. For larger volumes machinery will be needed. Truck loader backhoes (TLB) and front-loading tractors are best suited to the job.

Finally, to make deliveries the company will need tricycles or trucks. This depends on the volumes of the orders and the total volume of compost being produced. Those companies that have a peak in delivery during the mango season should consider sourcing two means of transport – one for deliveries and the other for collection of ingredients.

Figure 6. Illustrations of equipment required for compost production

Shredding equipment

Source: www.amazon.com

Various probes – temperature, moisture, pH

Source: www.takealot.com

Turning equipment – TLB or shovel

Source: www.canva.com

Transportation equipment – tricycle

Source: www.madeinchina.com

The equipment needed for producing compost using the aerobic method described above is relatively cheap. Quality equipment is estimated to cost about €2,596, assuming that the transportation can be leased. This also assumes a 20% import tax. This is a reasonable cost of investment. In this model we assume that quality equipment is purchased and shipped from South Africa. However, it can be sourced from elsewhere provided that it is robust equipment that can manage the shredding and can be easily repaired.

Table 7. Estimate of investment costs, based on South African prices (August 2022)

	ZAR	€	CFA
Woodpro 100 Crusher	30,500	1,826	1,198,084
Exchange pieces	1,500	90	58,922
Thermometer	275	16	10,802
pH meter	250	15	9,820
Humidity	250	15	9,820
Transport	3,340	200	131,200
Total	**36,115**	**2,163**	**1,418,649**
Customs duty			
+10%	3,611	216	141,865
+20%	7,223	432	283,730
+30%	10,834	649	425,595
+40%	14,446	865	567,460
Total cost estimate (20% customs duty)	**43,338**	**2,596**	**1,702,379**

4 Ingredients for success

4.1 Cheap composting ingredients

Compost is more expensive than mineral fertiliser, which is a real disadvantage. It is important then, to create a final product that is as affordable as possible for farmers. Being able to source cheap composting ingredients is thus an important ingredient for success. Waste is the best option as this is sometimes available at no cost. However, it is also important to not be overly reliant on any one ingredient. Finding multiple options for key ingredients is a key step in developing some resilience in the composting business. This requires a good awareness of the agricultural calendar and where different sources of ingredients could be found.

It is still possible to produce a more costly compost, enriched with more expensive ingredients. However, it might be a second or third product in the product range.

4.2 Sales

Moving compost is costly. So, it is ideal that customers are close to the composting site. These must be paying customers, who can afford compost.

4.3 Good composting techniques

As quality is important it is important to observe good composting techniques. This requires practice and experience as well as knowledge.

Mango waste especially needs careful attention to avoid fermentation. Once mango compost is acidic, lime needs to be added to correct the pH. This makes the product unnecessarily expensive and possibly unprofitable.

Whole mango pips cannot be added into the mix, so they need to be handled before composting. Most mango processing factories will not separate the peels, pips and flesh. However, if they are separated, they need to be transported separately to avoid mixing them and to make preparation of the pips simpler. A chipper should be used to shred the pips.

4.4 Finance and cash flow management

The investment costs in the business are relatively low. However, it still requires that the company invests in shredding equipment and at least a tricycle for deliveries.

4.5 Logistics and planning

A successful compost company will be able to sell compost throughout the week. But this requires careful planning to ensure that there is a pile maturing at least every 2 days. The company will thus have to plan the collection of ingredients so that there are no long gaps in deliveries.

On the other hand, they need to also plan to sell and deliver compost as each pile matures. The space will be needed to build a new pile and for turning of the piles.

As turning and watering are so important to the composting period, the management team will need to plan staff hours well – ensuring that there is always someone available to carry out these tasks.

Finally, maintenance of equipment needs to be planned. Knives need to be cleaned and sharpened regularly. Regular, scheduled maintenance is required for tricycles, trucks and shredders.

4.6 Seasonal calendar

It is important that the business can sell compost for most of the year. This builds up a reliable client list and helps to keep the business working professionally. But the mango season is short. As a result, the company should develop recipes that change as the agricultural season progresses. When rice is being harvested and its waste is plentiful, then this is a good core ingredient. When vegetables are being processed for export or for use by airlines, food services or to be sold to retailers, then this is a good ingredient to use.

The mango season starts and finishes later or earlier in different years. It is important to pay attention to these seasonal changes so that the company can change recipe as ingredients become available and as costs change.

4.7 Issues and opportunities summary

Table 8. Issues and opportunities

Opportunities	Issues
▪ Growing interest from consumers and retailers for organic, food-safe product. This increases demand for compost in certain niche supply chains. ▪ Compost is affordable to producers who intensively cultivate vegetables, spices, etc., and for high-value products. ▪ Investment in outgrower models securing finance for compost and other inputs. ▪ Increasing number of NGO and development programmes that target soil fertility. ▪ Many more sources of waste from processing, especially from mango and poultry droppings. ▪ Relatively simple production process. ▪ Low investment costs.	▪ Not a very affordable product for most small-scale farmers, especially if they do not have pre-financing for inputs. ▪ The production process might be simple, but it requires discipline and attention to detail to get a quality compost. Technicians must show discipline in carrying out their watering and turning duties. ▪ When using mango waste the ingredients must be carefully selected, prepared and blended to prevent the pile from fermenting rather than decomposing. ▪ Operations and logistics require consistent management. ▪ Ingredients need to be sourced daily, which can be a challenge as the agricultural season changes. ▪ Any change in ingredients will need new recipes to be developed, which might be more than most new composters can manage on their own. ▪ Transport costs can quickly escalate if customers are too far away and the company is not reliably setting delivery prices.

4.8 Conclusion

Composting is an opportunity for new smaller companies, or even for established input dealers looking to secure new products for their customers. Mango companies would generally find this activity a distraction from their core operations.

Success requires that companies identify customers in high-value niches, and those farms that grow produce intensively. This makes compost affordable and, in many cases, allows them to access finance to purchase inputs. Composting companies will need to become skilled in sourcing ingredients and in managing changing prices and availability of ingredients throughout the agricultural season. Learning how to blend new recipes is thus an important skill to develop. This could prove to be challenging for many young investors and could be an area where they need to find specific technical support. NGOs, research institutes and development organisations have an important role to play in developing recipes and sharing this knowledge.

The growing number of mango processing companies and their rising waste volumes creates opportunities for compost companies. However, there are some technical and operational issues that company management would need to solve – especially if they opt to make mango waste compost. They would need to learn how to select, shred and blend sensible combinations of ingredients to ensure that the compost does not form a sludge, as this will ferment rather than decompose. The recipe should also balance the carbon and nitrogen contents. The pile should also be turned and watered regularly to ensure that oxygen circulates throughout the pile and so that the ingredients decompose rather than ferment. This requires discipline and access to affordable, portable equipment.

The cost of transporting heaps of compost also requires access to reliable transportation. Transport is needed to continuously collect ingredients and then to be able to make ongoing deliveries throughout the season. Keeping a close eye on the distances between customers and the composting facility is key, as it enables the company to control costs, maintain profits and keep the compost affordable for farmers.

SECTOR STUDY: PROCESSED MANGO

1. Fresh cut mango
2. Dried mango
3. Mango puree
4. IQF mango
5. Mango pickle
6. Mango vinegar
7. Mango butter
8. Mango briquettes
9. Mango based compost

GROWING PEOPLE