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SECTOR STUDY
PROCESSED MANGO

2. Dried Mango

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FIT FOR MARKET SPS

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This document is part of the mango sector study. This study explores the technical and economic feasibility of different processing and waste valorisation activities. The other chapters are available here: resources.colead

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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).

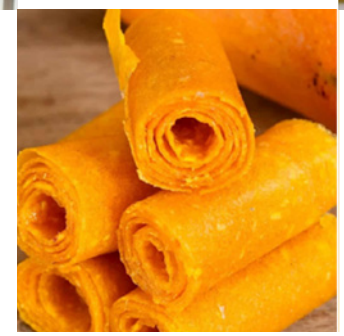
Air-dried mango

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.

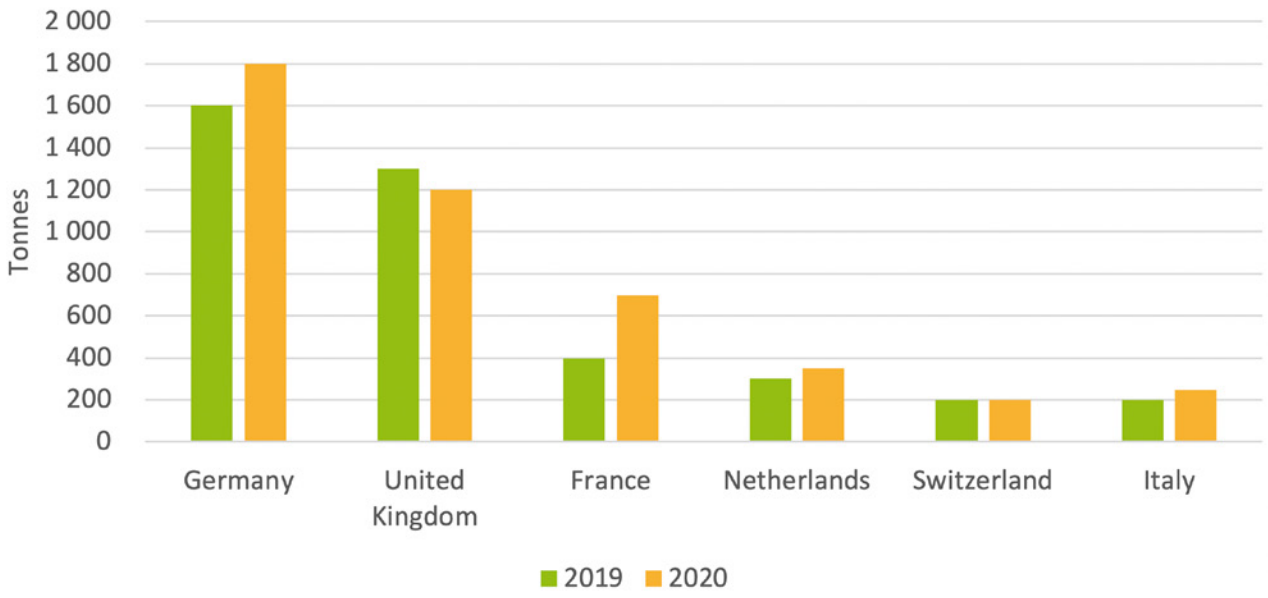


Figure 2. Main European consumers of dried mango, in import volumes (net re-export) (2019–2020)
Source: Autentika Global based on industry estimations.

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.

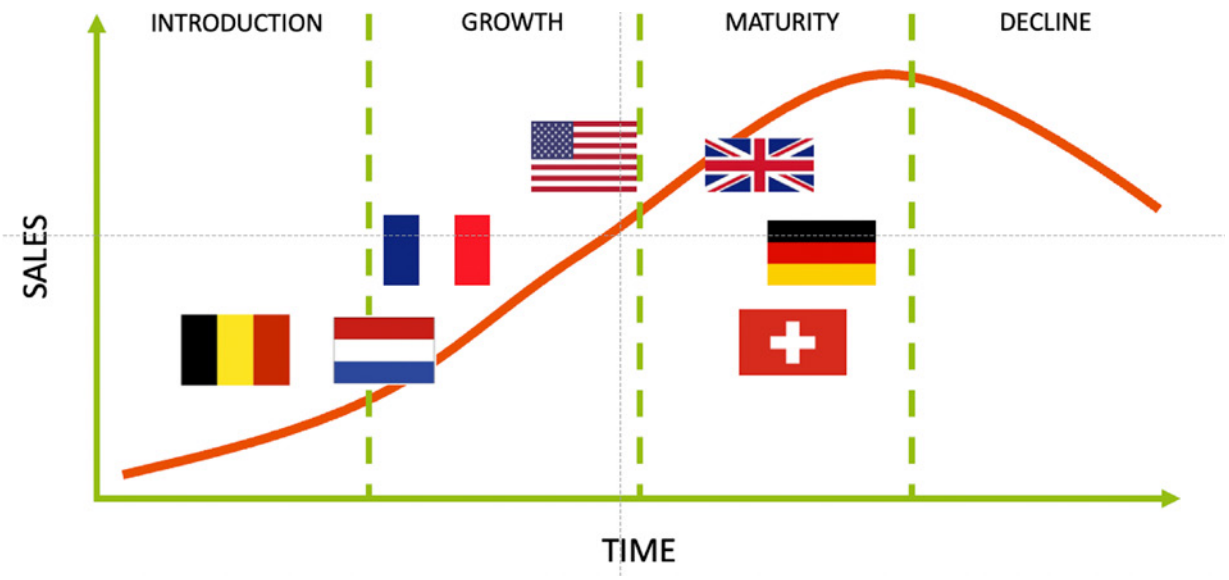


Figure 3. Market lifecycle

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?

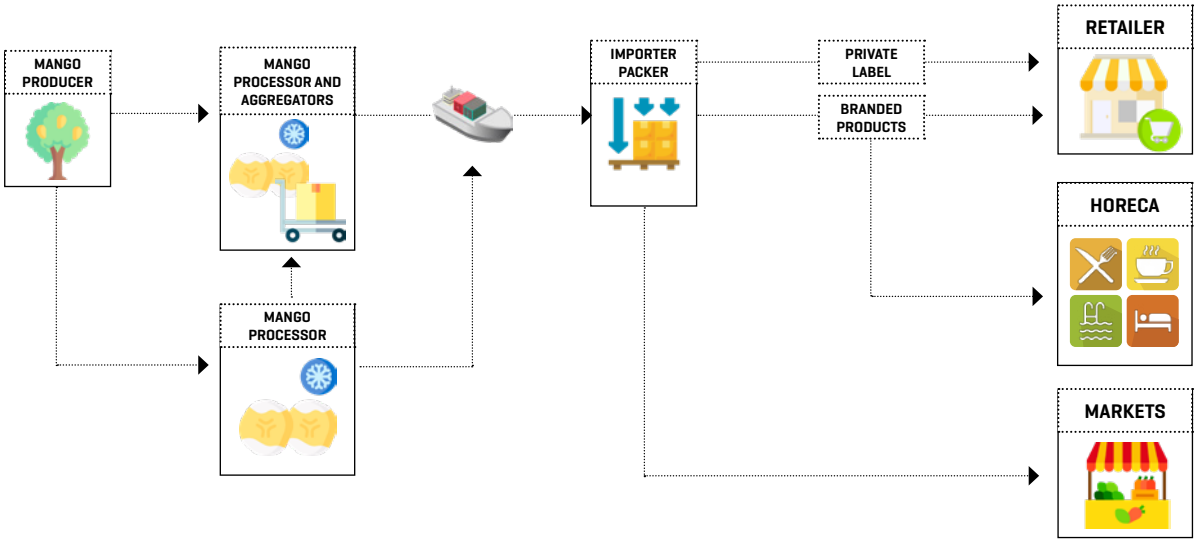


Figure 4. Dried mango value chain

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

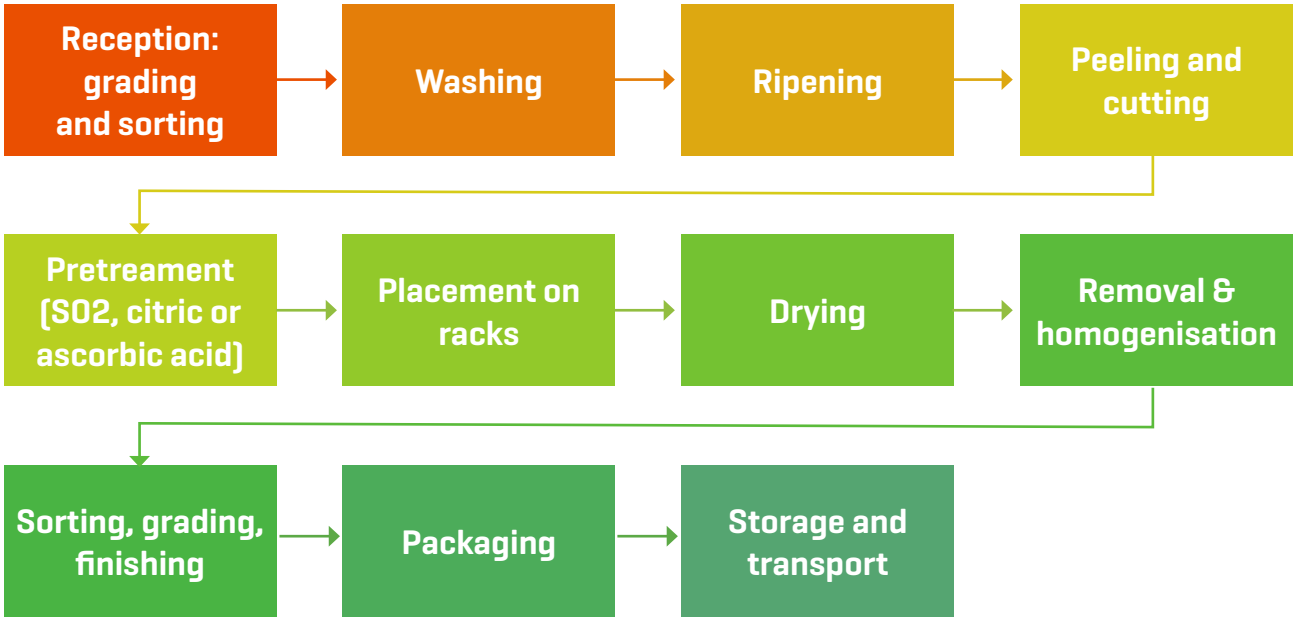
Figure 10. Moisture analyser

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.

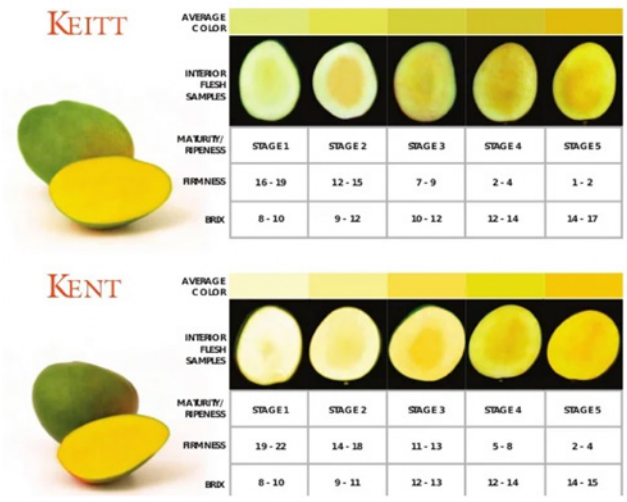


Figure 15. Keitt and Kent variety ripeness charts

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.

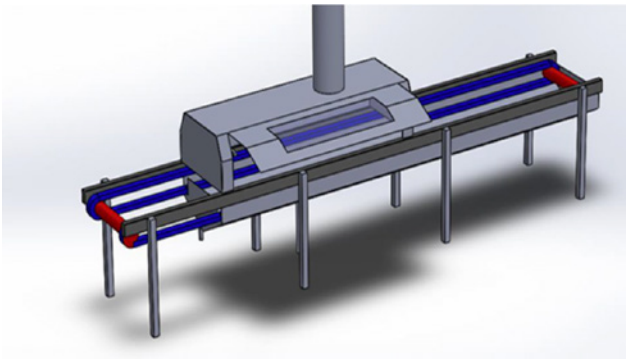


Figure 18. Spraying machine

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

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

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

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