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SECTOR STUDY PROCESSED MANGO

9. Mango Compost

Funded by the European Union

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FIT FOR MARKET+

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

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.

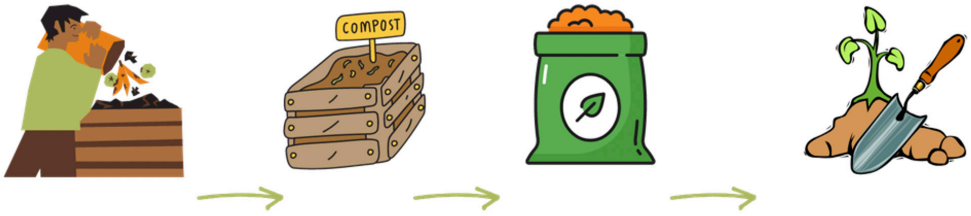

Figure 1. A generic composting process

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?

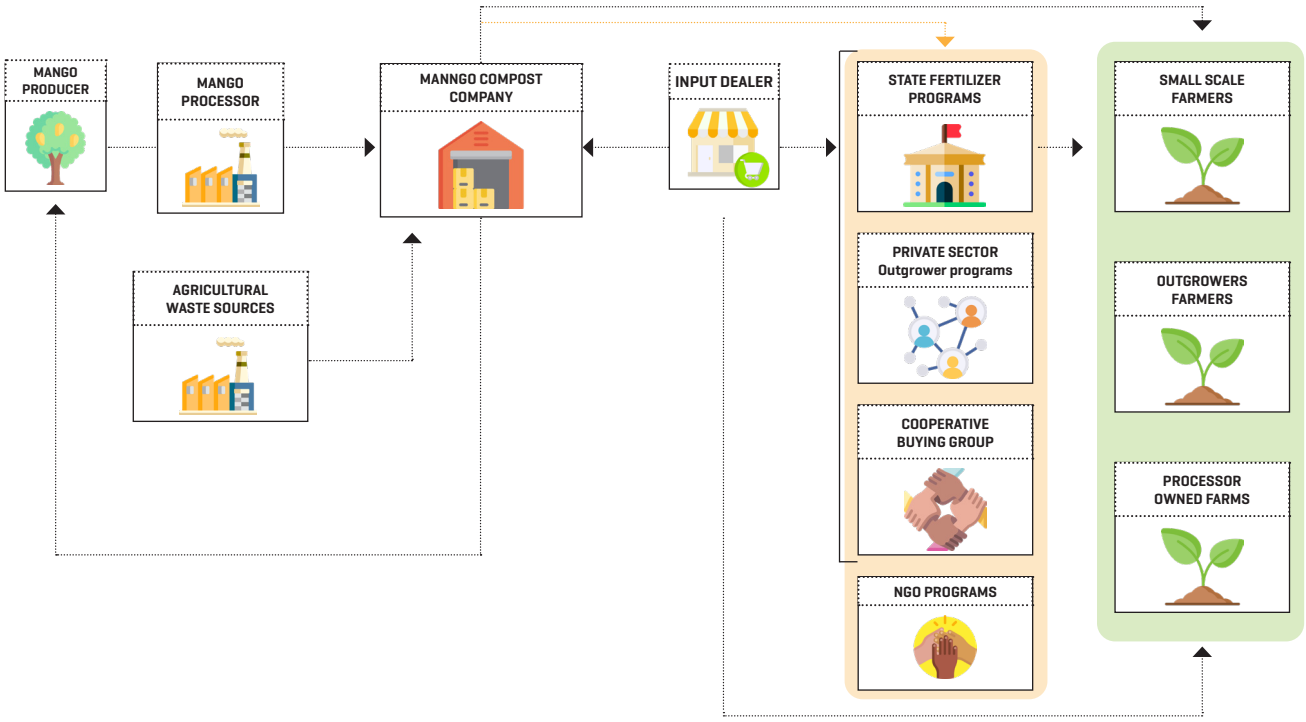

Figure 2. Overview of the compost and fertiliser value chain

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.

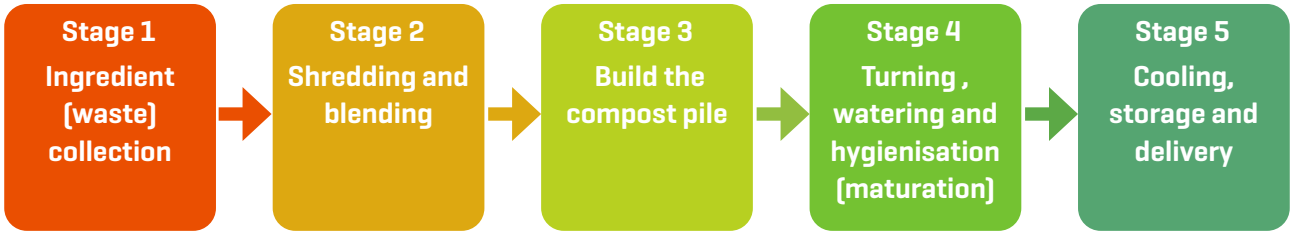

Figure 3. Production process for mango waste compost – aerobic technique

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)

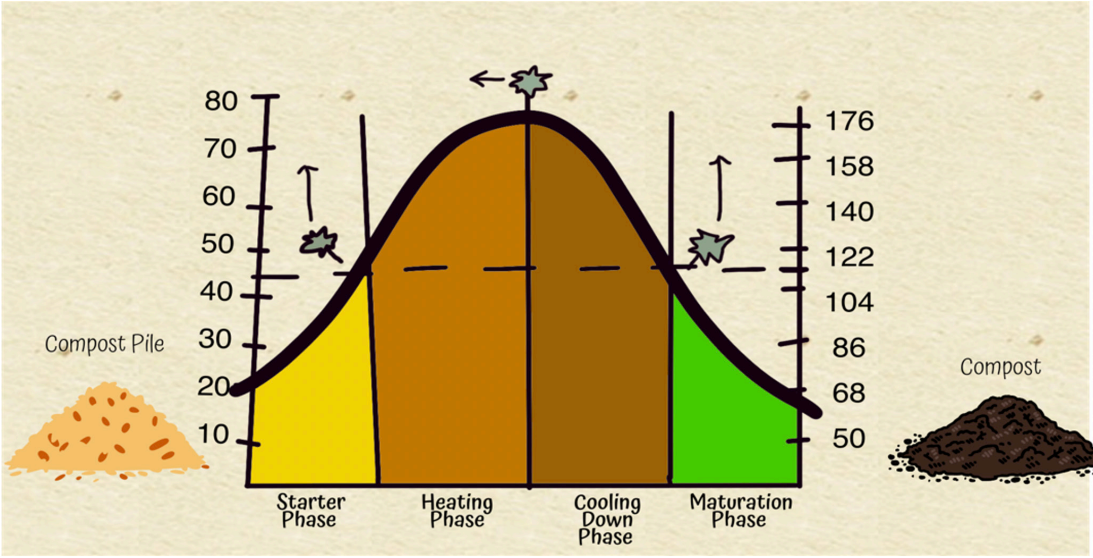

Figure 5. Production process for mango compost waste

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

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