BLACK SOLDIER FLY PRODUCTION

FARMERS GUIDE

I. Black Soldier Fly Production

Farmers Guide

Instruction manual for Kenyan smallholder farmers to start with the production of Black Soldier Fly Larvae as substitute for omena and soy in animal feed.

Glossary

5-DOL:	Stands for 'Five Day Old Larvae'. These are the larvae which are introduced from the hatchery towards the smallholder farmers.
Adult:	The last stage of the BSF. The state where they are ready to mate and actually are flies.
BSF:	Black Soldier Fly, *Hermetia Illicucens.*
BSFL:	Black Soldier Fly Larvae.
Fifth instar:	Harvesting stage of the BSFL, during this stage the larvae get a beige color and have the highest protein content.
Kitchen waste:	Leftover, organic matter from kitchens, restaurants, hotels and households.
Prepupae:	Stage right before the insect turns into pupae.

Pupae: Pupation or transformation stage of insects which undergo a metamorphosis. Turning from larvae to nymph or butterfly.

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1. Introduction

2. The problem

Agriculture is Kenya's most important sector. In 2017, 34% of Kenya's GDP and 65% of the total export of Kenya were because of agriculture (The World Bank, 2018).
In total, 63% of all food produced in Kenya originates from smallholder farmers (Balancing Act, 2018). Smallholders produce the majority of Kenya's agricultural products, but their yields are low. To reduce hunger, it is important to increase the productivity of the smallholders in this country.
A big problem in the current agricultural sector of Kenya are the high prices for animal feed due to high protein prices. For chicken, feed is around 60-70% of the total production costs (FAO, 2007). For pigs, feed is around 80% of the production costs (FAO, 2012). Of these percentages, around 60% of the total

feed costs are because of protein (Kimuge, 2019). These high protein prices lead to low-quality and very expensive animal feed.
We realize that the current situation is unfair towards farmers and want farmers to receive a fairer income. Therefore, several SMEs offers farmers an outcome with the Farmer Outgrow Model. With this model we want to offer farmers an opportunity to receive 5-DOLs from us and grow their own protein-rich animal feed on waste materials.
The production of the BSF on the waste products of smallholder farmers gives farmers an opportunity to produce protein rich animal feed without having to buy expensive animal feed with foreign protein sources as soybean- and fishmeal. The usage of the black soldier fly larvae as feed would decrease the costs of animal feed for farmers and can lead to a more food secure economy.

3. The starter-kit

Because we think that all farmers need access towards high-quality animal feed, we offer a special starter-kit for smallholder farmers. These are farmers with a maximum of 100 chicken or 30 pigs.
The starter-kit contains the products shown in *figure 2* and will sell for KES 6000. With the implementation of the starter-kit, a farmer is able to produce a maximum of 2.5 kgs of Black Soldier Fly larvae per crate, this leads to a total of 12,5 kgs of BSFL every two weeks.
If the farmer wishes to have a higher production, more crates can be bought for KES 750 per crate.

Figure 1: Starter-kit offered to farmers

2. Why Black Soldier Flies?

Before explaining why Black Soldier Flies are relevant for smallholder farmers, we need to explain what BSF is and where it originates from.
The black soldier fly is a common and widespread fly in many tropical regions, but the BSF originates from South America. Because of human actions, the fly was able to spread to other tropical, sub-tropical

and warmer regions. The BSF has the ability to adjust to different circumstances very quickly. But, in contrast to the housefly, the BSF is not a pest (de Baets, 2017). This, since they do not bite, sting and are not able to transfer zoonotic diseases.
The larvae of the BSF are able to concert organic waste towards protein. The protein content of the dried BSFL is between 35 and 50 percent.
The adult flies *(figure 2)* are between 15 to 20 millimeters long. Adults do not have a mouth, therefore, the larvae consume a lot of organic substrate during their larval stage. The larvae are able to feed quickly and can reach their harvesting stage (*figure 3*) in 10 to 14 days.

Figure 2: Adult Black Soldier Fly

Figure 3: Black Soldier Fly Larvae

The dried larvae can be used as a substitute for soy and omena/fishmeal in animal feed. The larvae can survive a lot of environmental differences and are therefore a suitable implementation for farmers to produce themselves. They are able to survive huge differences in temperature, humidity and feed substrate. They do prefer a warm temperature (around 27 degrees Celsius). When the temperature gets too high (above 30 degrees Celsius) or too low (under 25 degrees Celsius), the developing time of the larvae will increase, but the larvae are most likely to survive. This makes it easy for farmers to produce. Besides the low work-load, the production of the BSFL leads to an eventual decrease in feed costs, since the buying and production of the larvae is cheaper than buying omena and/or soy.
Besides, the production of livestock on BSFL leads towards higher revenues since the pigs have a developing time of 4.5 months instead of 7 months, and the meat is of higher quality (Mulderij, 2019). For layer hens, their laying period extends which leads to an average increase of 62% more eggs. The eggs have thicker shells and the yolk is more yellow. And lastly, broilers fed on BSFL are on average 10% more heavy than broilers which are not fed on BSFL (ICIPE, 2017).

3. How to produce them?

4. Prepare yourself

Before you can start with the production of BSF, several products need to be available on the farm. Firstly, for hygiene aspect several pieces of protective clothing are recommended. These are; a pair of overalls, non-dispatchable rubber gloves and a pair of gumboots. This will protect your clothes and shoes from getting dirty and will protect your hands from bacteria. Besides, the protective clothes protects the BSFL from bacteria and mites. Make sure the gloves and boots are cleaned regularly, and the overalls are washed on at least a monthly basis. For visitors, dispatchable rubber gloves can be bought.

Figure 4: Clothing checklist BSFL production

Besides only clothing, several other essentials for BSFL production are needed. All essentials are shown in *figure 6*.

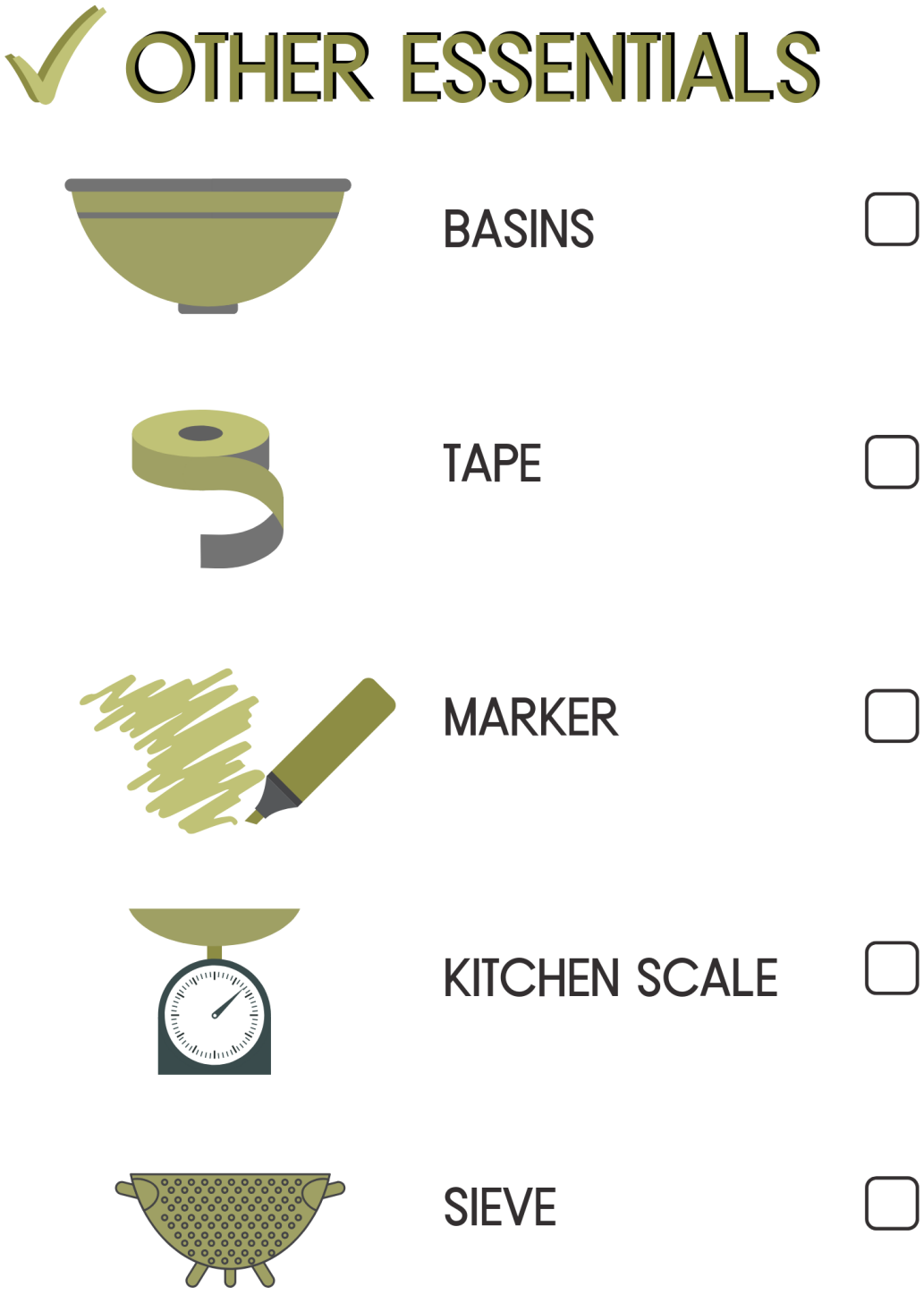

Figure 5: Other essentials for BSFL production

Basins are needed to grow the larvae in. depending on the size of your farm, the amount of crates needed can be calculated. For example; a farmer with 30 chicken needs only 2 crates, and a pig farmer with 10 pigs needs 8 crates to replace the recommended protein content with BSFL.
Tape and markers are needed to mark the crates with the date of the start of the production, this keeps everything structured.

A kitchen scale is needed to measure the amount of kitchen waste and manure. Besides, a scale can be used to measure the harvest. Lastly, a sieve is needed to separate the BSF manure and skins from the harvesting-ready larvae.

5. Preparing feed substrate

The project delivers bags of 5-DOLs towards the farm. Each bag of 5-DOLs needs 12 kg's of feed substrate. The feed substrate can be a mixture of animal manure and different kinds of kitchen waste. The recommended amount is 60% animal manure and 40% kitchen waste *(table 1)*. Research has shown that the larvae fed on a percentage with this substrate had the highest harvest outcome.

Table 1: Ratio's feed substrate

	Kitchen waste	Manure	Total
%	40	60	100
Kg	4,8	7,2	12

It is recommended to cut the kitchen waste into smaller pieces before mixing, the larvae are then able to consume the substrate better and faster. It is also recommended to first create a substrate out of kitchen waste *(figure 7)* before mixing it with the animal manure.
All different kinds of waste which can be fed to the larvae is shown in *figure 9*.

Figure 6: Example kitchen waste substrate

When the kitchen waste substrate is mixed through correctly, animal manure can be added into the BSFL crates. Afterwards, the kitchen waste substrate can be mixed with the manure to create the final feeding substrate.

When the feed substrate is ready, a bag of larvae needs to be added in each crate (*figure 8*).

Figure 7: 5-DOL with substrate

One bag of larvae with substrate weighs 100 grams and can lead to a harvest between 1.8 kg and 2.5 kg of end product.
The amount of harvest depends on several factors;
feed substrate, temperature and relative humidity. When the feed substrate does not contain enough nutrients, the larvae tend to be smaller and have a longer development time.
When the larvae are active, the temperature in the crates increases. The recommended outside temperature is between 25 and 35 degrees Celsius. This leads to a higher productivity and development rate of the larvae. For humidity, the feed substrate needs to have a high water content. When the feed substrate is pressed together in one hand, it needs to stick together, but only a little bit to no water has to come out of the substrate, this can be seen in *figure 10*.

WHAT TO FEED THEM?

Figure 8: Ingredients feed substrate

Figure 9: Moisture content feed

INSTRUCTIONS

1. Cut kitchen waste into small pieces.
2. Make a kitchen waste feed substrate *(figure 5)*.
3. Add 7,2 kg's of animal manure into each crate.
4. Add 4,8 kg's kitchen waste mixture to each crate.
5. Mix through.
6. Check moisture content - too dry? Add water.
7. Check moisture content - to wet? Add bread. crumbs.
8. Add 1 bag of 5-DOL to each container.
9. Stack containers on top of each other.

Figure 11 gives an overview of all steps which need to be followed for the making of the feed substrate for the larvae.

6. Risks

The production of the larvae has a few risks which are not severe. These risks are; mites, birds and houseflies.

- Birds are attracted towards the larvae and are likely to consume them when possible. To decrease this risk, a net can be placed on top of the crates.

- Mites can be recognized because of their red colour. They feed themselves on the blood of the larvae. Mites are attracted towards chicken manure. When the larvae are contaminated with mites, the time before the larvae reach harvesting stage can be extended. After harvesting crates with chicken mites, the crates need to be cleaned and dried properly.

Figure 10: Chicken mites attached to the larvae

- The pupae of houseflies can be recognized because of its colour and shape. Houseflies are no threat for the larvae, but they are in competition because of the feed substrate.
  The developing time of the housefly larvae is shorter and therefore they do not form a big risk.

6.4 Harvesting

The harvesting of the BSFL needs to happen when the protein content of the larvae is the highest. This can be recognized by their beige colour. Before harvesting stage, the larvae have a white colour. When the larvae are past their harvesting stage, they turn into a black/grey colour and are most likely to escape the crates. The difference in these stages can be seen in figure 10.

Figure 11: When to harvest

The harvesting can be done by sieving. A sieve will be part of the smallholder starter kit. The process of sieving can be seen in *figure 11*. The manure/frass received from the sieving process can be used as fertilizer on land.

Figure 12: Sieving BSFL

The end products are then the larvae in harvesting stage (*figure 12*) and the manure of the larvae (*figure 13*).

Figure 13: Larvae in harvesting stage

Figure 14: Frass/manure of larvae

7. Processing

After the harvesting of the larvae, they need to be processed. For chicken, the larvae can also be fed alive (this does not count for pigs). The cleaning of the larvae needs to be done via blanching. The larvae need to be boiled for 3 minutes in water. This to kill and clean the larvae and kill bacteria. After this process, the larvae need to dry in the sun. let them dry for two weeks. Then the final product is ready, which can be fed to pigs and chicken.

Figure 15: Processing of larvae

When the product is ready (*figure 19*) it can be fed to pigs and chicken. As stated before; pigs have a replacement rate of 75% for protein. The replacement rate of protein for chicken is 50%.

Figure 16: Final end product: dried BSFL

8. Cleaning

When the processing of the larvae is done, the crates can be cleaned. This needs to be done properly to reduce any risks and create a hygienic environment. The crates need to be washed with warm water and soap. Disinfectant can be used afterwards to kill present bacteria. Let the crates dry at least one day before using them again.

9. Summary production process

This chapter shows the overview of the production process, first via images (*figure 17*) and then step-by-step via a flowchart (*figure 18*).

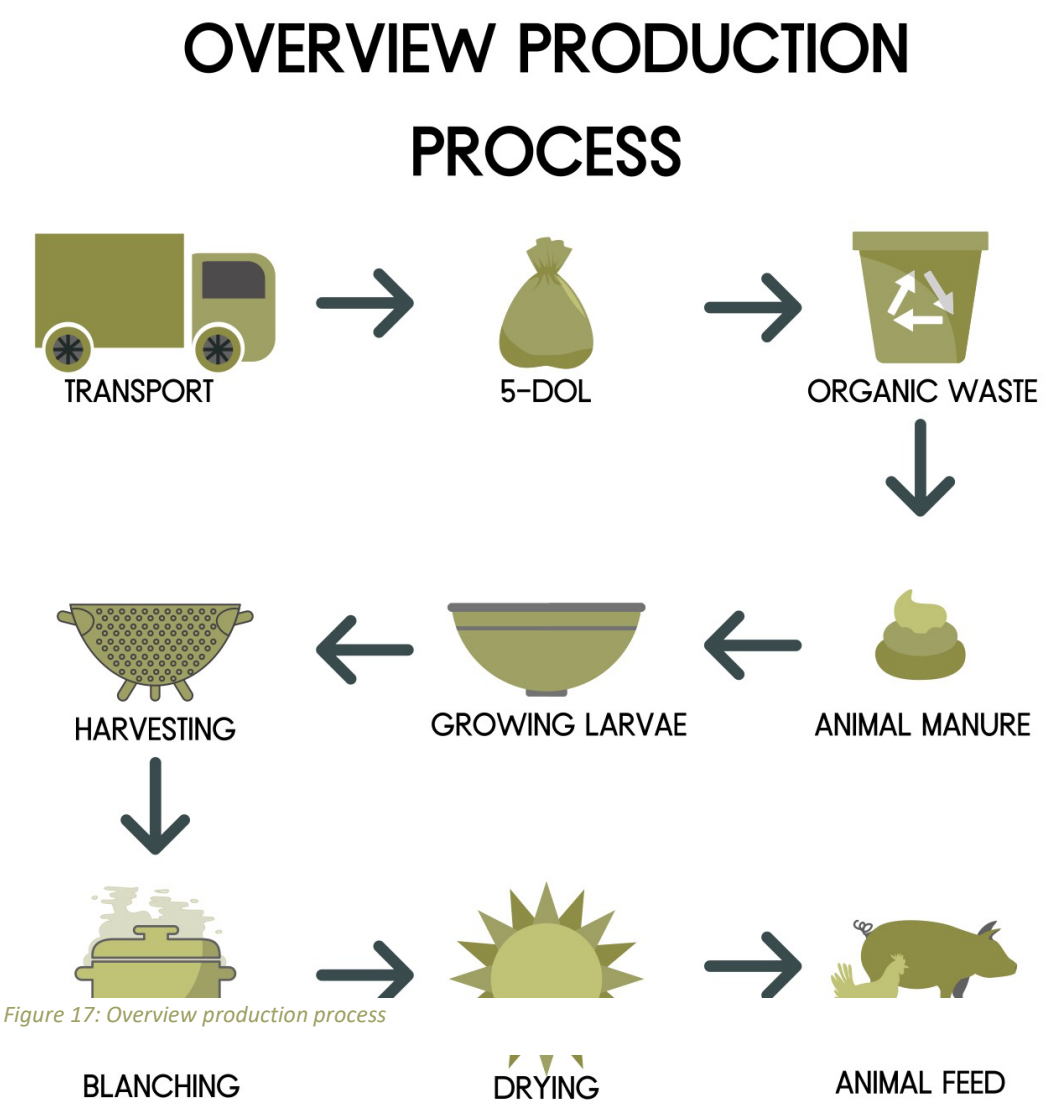

Figure 17: Overview production process

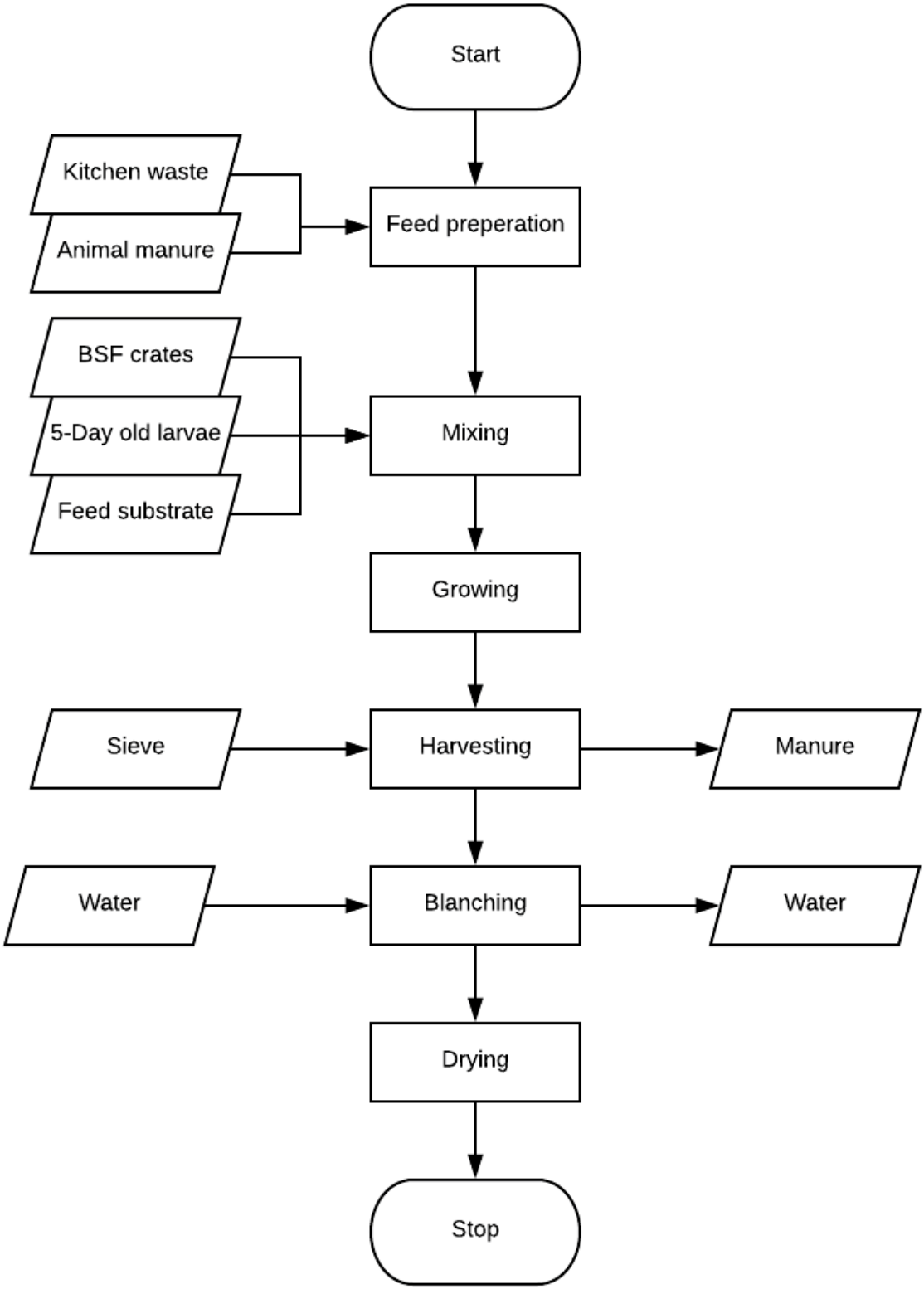

Figure 18: Step-by-step guide

4. What are the costs?

5. How many crates do I need?

The replacement rate of the protein is not 100%. This means that omena/fish meal or soy still need to be added to the feed mixture. The replacement rate for pigs is 75%, for chicken it is 50%. This, since research has shown that these percentages lead to the highest value for the end-products of the animals (meat and eggs).
With these percentages, the amount of crates desired for production of the amount of protein needed to feed the animals can be seen in table 2 and 3.

Table 2: Crates needed pigs

Pigs		
Amount animals	**Replacement rate**	**Crates needed**
10	75%	8
15		12
20		16
25		20
30		24

Table 3: Crates needed chicken

Chicken		
Amount animals	**Replacement rate**	**Crates needed**
10	50%	1
25		1
50		3
75		4
100		5

The starter-kit (figure 2) can be bought for KES 6000 and can produce between 9 and 12,5 kgs of larvae every two weeks. The starter-kit contains;

- 5 crates
- 5 bags of 5-DOL
- An overall
- A sieve
- A pair of non-dispatchable rubber gloves

Since it takes around two weeks to grow the larvae, it is recommended to buy twice the amount of crates needed. This, so you can produce enough protein to reach the replacement rate every week. Crates can be bought for KES 750 per piece and are a one-time investment. Larvae need to be bought every time a production cycle is completed. This can be every week or every two weeks, depending on the amount of crates a farmer has. One bag of larvae needs to go in each crate and will cost KES 150 per bag.

Table 4: Comparison feed prices in Kenya

Comparison between feed prices

	Feed prices		
	Omena	Soy	Average
	Ksh	*Ksh*	*Ksh*
Kg	KES 150,00	KES 100,00	KES 125,00

	Feed prices BSF
	Ksh
Kg	KES 75,00

For a farmer with 30 chicken, the weekly decrease of feed costs is able to decline with 28%. A farmer with 10 pigs will notice a total decrease in costs of 8% per week.
Even though the decrease in costs for pig production is lower than for chicken production, farmers are still able to save a lot of money since the pigs fed on BSF have a shorter period of growing (4.5 months instead of 7) and the meat quality is higher, which leads to higher profits.

6. Cost reduction 10 pigs

	Feed ratio's per week			
	Per pig		Per 10 pigs	
	Feed (kg)	Protein (kg)	Feed (kg)	Protein (kg)
Amount	21	2,625	210	26,25
Percentage	100	12,5	100	12,5

Pig smallholder starter kit (10 pigs)

	Current situation		Future situation			
	Average (kg)	Price	Average (kg)	Price	BSFL (kg)	Price
	26,25	KES 3.281,25	21,00	KES 2.625,00	5,25	KES 393,75
Total:		**KES 3.281,25**				**KES 3.018,75**

-8% decrease in feed costs on a weekly basis

7. Cost reduction 30 chicken

	Feed ratio's per week			
	Per chicken		Per 30 chicken	
	Feed (kg)	Protein (kg)	Feed (kg)	Protein (kg)
Amount	1,12	0,00	33,6	7,39
Percentage	100	22	100	22

Chicken smallholder starter kit (30 chicken)

	Current situation		Future situation			
	Average (kg)	Price	Average (kg)	Price	BSFL (kg)	Price
	7,39	KES 924,00	2,14	KES 267,75	5,25	KES 393,75
Total:		**KES 924,00**				**KES 661,50**

-28% decrease in feed costs on a weekly basis

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