Circular Eco-feed chain for responsible pork consumption and production at Curaçao

A first exploration

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This research project has been carried out by Wageningen Food & Biobased Research commissioned by the Dutch Ministry of Agriculture, Nature and Food Quality and funded by Topsector Agri&Food, in the context of SMP-1981: Circular eco-feed chain for responsible pork consumption and production at Curaçao
(project number 6234180400).
Wageningen Food & Biobased Research
Wageningen, February 2020

Public

Report 2023
https://doi.org/10.18174/515344

WAGENINGEN
UNIVERSITY & RESEARCH

Version: final
Reviewer: Sanne Stroosnijder
Approved by: Nicole Koenderink
Client: the Dutch Ministry of Agriculture, Nature and Food Quality
Sponsor: Topsector Agri&Food
Project number (internal): 6234180400

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Contents

Preface

For realisation of this SMP project we would like to thank all partners who have contributed to and/or supported the project. The team of researchers from Wageningen Research in combination with the Chief Veterinary Officers from Curaçao and The Netherlands have worked successfully together to collect and analyse in a short time the needed information.

We are grateful for the input and interest of the consulted stakeholders on Curaçao. This interest is essential for performance of next steps towards a "coalition of the willing". Also the involved partners in the Netherlands, Europe, and even Japan have shown their interest during the project and are looking forward to the outcome and possible opportunities for them (e.g. Ten Have Mellema Varkenshouderij, Princepeel Varkenshouderij, Kipster, Nijsen/Granico, Global Feedback (UK) and University of Miyazaki (Japan)). We hope that the outcome of this project will be taken up further in other projects and initiatives on this topic, like the planned Public Private Partnership research project executed by Wageningen Research and partners and a possible investment in an Eco-feed plant on Curaçao.

Summary

Seed Money Projects are a tool used by the Dutch Ministry of Agriculture, Nature and Food Quality via the topsectors Agrifood and Horticulture and Starting Materials to support new international partnerships for Dutch companies and SMEs in the Agri& Food and Horticulture & Starting Materials sectors. The aim of this Seed Money project, is to explore the feasibility of a concept for a circular Eco-feed chain for responsible pork consumption and production at Curaçao. Another goal is to create a "coalition of the willing" to make further steps in creating the required chain when the concept exploration turns out to create good opportunities and value for stakeholders at Curaçao and potentially also for European and Dutch stakeholders.

The innovation is based on the concept of Eco-feed. This system applies a safe process for upcycling food waste, specifically from retail and out-of-home channels, into a safe and high quality pig feed. Use of streams that contain animal derived components is forbidden in the EU because intra-species feeding of animal proteins is not allowed and they can play a role in the spread of animal diseases like Food and Mouth Disease (FMD), Classical Swine Fever (CSF) and African Swine Fever (ASF). Only a strictly defined set of animal-derived components is allowed in feed under very well-controlled controlled conditions. Although on Curaçao this application is not legally prohibited, unsafe practices should be prevented there too.
The intended Eco-feed concept consists of a safety-oriented food waste collection system and a processing plant customized for Curaçao. In addition the nutritional value of the pig feed may be enhanced and standardized by adding specific components. Thus, this project creates an opportunity for development and professionalizing of the pig production sector in Curaçao by:

- preventing the introduction of animal diseases through feed;
- improving the availability of local pig feed;
- increasing the nutritional value of locally produced pig feed;
- contributing to a solution of an existing problem of dioxins in local pig meat:
    - control of the ingredients in feed,
    - eliminate current practice of burning packaging materials by pig farmers.

The concept of Eco-feed was prioritized by the EU-REFRESH project[1] as the technology option that has highest impact on food waste valorization. Based on an example surplus food composition it was concluded that the feed has an attractive feeding value (when used in combination with complementary feed). Compared to use of untreated food waste for feed in many countries, amongst which Curaçao, this project guarantees safe treatment of food waste, so that unsafe food practices and feed-induced animal diseases (such as swine fever) can be prevented. The technology is operational on an industrial scale in Japan, and operationalized in various other countries.

In this SMP study, the available food waste streams on Curaçao, from supermarkets, restaurants, hotels and cruise ships, are estimated at 1000 tonnes per year. This would largely cover the feed needed for the current pig farming sector on Curaçao. Because the locally produced pig meat is highly appreciated, and only a small fraction of total pig meat can be sourced locally, there is room for growth of the pig sector.

With an eye on the positive outcomes of this study and clear interest from stakeholders on the island, first steps were made for practical development of a plant on Curaçao.

For more information about this report, please see the colophon of this report.

[1] https://eu-refresh.org/avoiding-food-waste-through-feeding-surplus-food-omnivorous-non-ruminant-livestock

1 Introduction

Curaçao, an island in the Caribbean and a country within the Kingdom of The Netherlands, is a net importer of pork. The consumption and import of pork increases over the years, mainly due to the demands by the expanding and flourishing tourist sector.

On the island a continuous flow of "food waste/food surplus" is generated by food-service, hotels, hospitality and retailing businesses. Currently, food waste is mainly used as landfill, which is not environmental-friendly and leads to a waste of valuable nutrients with negative environmental impacts (like methane production, a serious greenhouse gas). On the other hand all animal feed needs to be imported which makes animal husbandry relatively expensive. Consequently, the local production and processing sector for meat is organized in a low-tech and small scale manner.

The opportunity that is explored in the project, is a small scale circular "Eco-feed" chain for responsible pork production at Curaçao using processed surplus food as a source for nutritious feed, and a source for a premium quality pork meat. The aim is to "upcycle" the currently considered waste product to a valuable resource. This requires an adequate management of the residual flows plus processing to a nutritious and safe feed product. In this report the residual stream is still addressed as a 'waste' stream since it reflects the current practice.

Historically these surplus foods have been used to supplement the diets of omnivorous non-ruminant livestock. In Europe, this practice has been banned 15 years ago because animal diseases like foot-and-mouth disease (FMD), classical and African swine fever (CSF, ASF) can be easily transmitted through feed. However, as shown in the EU project REFRESH[2] in REFRESH (D6.13)[6] valorizing food waste that is generated in the distribution and consumption phase is essential to reach EU food waste reduction goals. REFRESH (D6.7)[4] describes how the Eco-feed can be safely implemented in a controlled processing chain. The outcomes of this project are used to explore the usage of surplus foods in animal feed for safe and nutritious animal feed in Curaçao, contributing to the circular agriculture. The data can be used to explore possibilities for this concept in the EU.

Using the latest insights and technologies, given the current situation, a modern and sustainable livestock sector could be set up in Curaçao, based on circular agriculture and circular economy principles (key policy areas for both the Dutch ministry of LNV as well as for the Min. Health, Environment & Nature of Curaçao). The overall potential benefits of this opportunity are a contribution to food security, food safety improvement, development of livelihoods, increased employment, self-sufficiency of high quality products, professionalization of the agrifood sector (including processing/added value activities) and promotion of sustainable tourism.

In some countries, like Japan, the concept of Eco-feed, has been applied successfully on a relatively modest scale since the 1990s, and gradually extended. This technological concept has some very interesting elements, and will be an important reference for this project. In the Japan situation, the feed price for the pig producers could be up to 40% lower, compared to imported feed. And due to the high quality of the feed, the consumer products are sold at a premium price level.

1.1 Aim

The aim of this Seed money project, is to explore the feasibility of a concept for Circular Eco-feed chain for responsible pork consumption and production at Curaçao. Another goal is to create a "coalition of the willing" to make further steps in creating the chain when the system turns out to create good opportunities and value for stakeholders at Curaçao and possibly from the Netherlands.

[2] EU-REFRESH was funded by the Horizon 2020 Framework Programme of the European Union. See http://eu-refresh.org.

1.2 Research method

The concept proposed to explore the potential of Eco-feed for Curaçao, is built highly on recent research by a group of European scientists and experts in the context of the EU REFRESH [3].

For this SMP project a team was set up to answer the key design questions, including global experts (Wageningen Research, Feedback, Japan Eco-feed), business operators and pork farmers, and governmental officials (including veterinary expertise).

Through market research and stakeholder interviews an analysis of the current and potential future situation was made. To determine the design parameters for the supply chain concept, additional knowledge is collected about the specific local context, like:

- Insights in the availability and quality of surplus food from professional operators (hotels/restaurants, and potentially also cruise boats, aviation industry).
- Insights in the market potential for locally sourced pork products.

With this type of inputs a design of a supply chain model at scale to fulfill market demands can be made and some design criteria can be identified (logistics, feed quality, processing facility, quality certifications, business model). Also some reflections on environmental & safety aspects are provided.

This report starts with a short introduction of the intended Eco-feed chain (chapter 2). Next, chapter 3 presents quantitative data with estimates of (food waste) supply and (pork) demand figures for Curaçao. These results were verified and opinions of stakeholders were analyzed in a stakeholder/fact-finding mission; conclusions are presented in chapter 4. Finally a reflection is given in chapter 5, and conclusions are summarized in chapter 6.

2 Introduction Eco-feed

The concept of Eco-feed is a safe process for upcycling food waste - specifically from retail and out-of-home channels - into a safe and high quality pig feed. It consists of a safety-oriented food waste collection system and a processing plant customized for Curaçao. In addition the nutritional value of the pig feed will be increased, optionally enhanced by adding specific components. Thus, this project creates an opportunity for development and professionalizing of the pig production sector in Curaçao by:

- improving the availability of local pig feed;
- controlling/improving the nutritional value of local pig feed;
- preventing the introduction of animal diseases through feed;
- contributing to solution of an existing problem of dioxins in local pig meat:
  - controlling the ingredients in feed,
  - eliminating current practice of burning packaging materials by pig farmers.

The concept of Eco-feed was prioritized by the EU-REFRESH project as the technology option that has highest impact on food waste valorization. Based on an example surplus food composition it was concluded that the feed has an attractive feeding value (when used in combination with complementary feed).

The technology is operational on an industrial scale in Japan was in practice formally in various countries worldwide. Compared to use of untreated food waste for feed in many countries, amongst which Curaçao, this project guarantees safe treatment of food waste, so that unsafe food practices and feed-induced animal diseases (such as swine fever) can be prevented. The Japanese technological setup is used as a reference for this project.

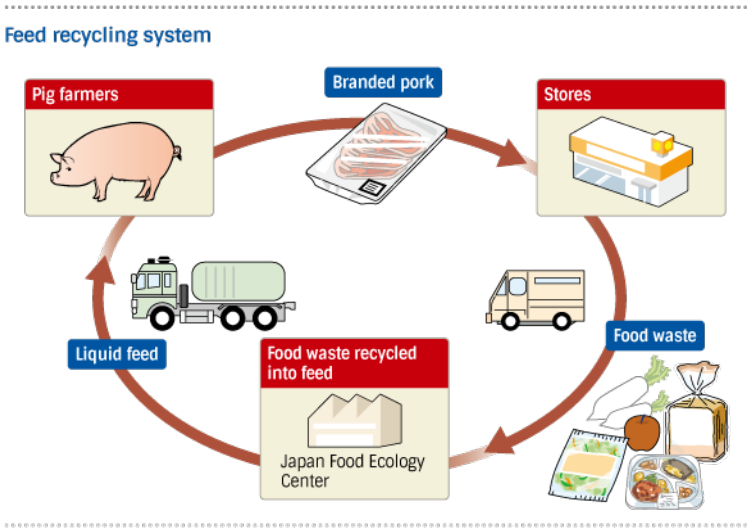


Figure 1. The concept of Eco-Feed, implemented by Japan Food Ecology Center[3]

REFRESH (D6.7) [4] concluded that safe implementation is possible when applying adequate quality management in the waste collection and processing phase. The key processing operations in the proposed Eco-feed plant are heat treatment (to deactivate/destroy microbial threats, including animal diseases) and fermentation/acidification (to extend the shelf life of the feed at ambient temperature), see details in Figure 2.

[3] https://asia.nikkei.com/Business/Japan-s-edible-waste-becomes-sought-after-pig-feed

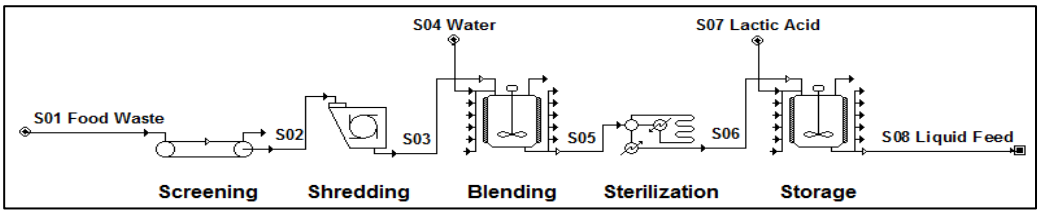


Figure 2. Intended unit operations in the Eco-feed plant

Techno-economic scaling evaluations by REFRESH (D6.11)[5] suggest that under existing European market conditions, medium-sized treatment plants can be commercially viable. The smaller volumes of food waste in Curaçao drive up processing costs, while on the other hand, reference feed prices in Curaçao are significantly higher than in Europe. This study will further explore the potential of commercially viable Eco-feed factories on Curaçao.

3 Market data analysis

This chapter presents a data analysis that supports the business case analysis of Eco-feed on Curaçao, specifically focused on available food waste volumes and (potential) demand for pig feed.

Curaçao is a country in the Caribbean with around 160,000 inhabitants. Because there is a lot of tourism there are always relatively many people on the island. Curaçao has a large oil refinery that (still) has an important share in the economy. The port is one of the largest in the Caribbean Sea region. The handling of containers and the presence of a large dry dock ensure that the port is visited every year by hundreds of large ships. Financial services (Offshore trade and the Free Zone) have been an important employer in Curaçao for decades. And then of course there is tourism, which accounts for around 20% of GNP[4,5].

The industry can accommodate around 15 percent of the working population. Ten percent of the population works for financial institutions and another ten percent works in the construction industry. There is also a very large civil service; seventy percent of government revenue goes to civil servants' salaries. Less than 1 percent of the working population of Curaçao works in the field of agriculture, fisheries, forestry and mining[6].

Figure 3. Map of Curaçao

3.1 International pork trade on Curaçao

The export of pork from Curaçao is negligible. With respect to import we used two data sources:

a) the UO[7] Veterinaire Zaken (part of the Ministry of Health, Environment and Nature of Curaçao)
b) UN Comtrade from the United Nations.

Since the figures differ, both statistics are elaborated in this report. The data from UO Veterinaire Zaken are considered more reliable, but the UN Comtrade data add economic value data, which is also considered valuable.

[4] https://nl.wikipedia.org/wiki/Cura%C3%A7ao#Economie, visited on 25-9-2019
[5] https://www.vakantie-curacao.nl/algemeen/economie-overheid/, visited on 25-9-2019
[6] https://www.landenweb.nl/curacao/economie/, visited on 26-9-2019
[7] UO = uitvoeringsorganisatie; executive organisation

The UO Veterinaire Zaken (UO VZ)

The UO VZ has the task to test and approve all meat imports and employees keep track of the unloaded goods in this context. The results for 2017 and 2018 are summarized in Table 1.

Table 1: Meat imports in Curaçao according to UO VZ

import to Curaçao (in tons)		
Meat category	***2017***	***2018***
Beef	3128	3520
Pork	2115	2165
Sheep	84	136
Goat	114	125
Wild	0.2	0.3
Other	0	0.5
Total	5441	5947

Since these data are from the government of Curaçao, they will be the base for further analysis. Nevertheless the UN Comtrade statistics are discussed below, since they are used worldwide as a solid source and copied in other well-known statistics like ITC[8].

UN Comtrade

The United Nations statistics are based on tax documentation as well. They collect data from both countries from the trade deal, exporter as well as importer. It happens that what is exported from country A to country B according to country A is not the same as what is imported in country B from country A according to country B. Such inconsistencies can be explained by various reasons[9]. Another explanation may be that only NACE code 20.329 is imported, which is a non-regular part of the pork.

The import consists almost entirely of frozen pork. The quantity fluctuates around 3000 tons per year (Table 2) and was in 2017, the last year for which data is known, 2,732 tons (there are data from 2018, but they are much lower, which could suggest the data are still incomplete).

Table 2: Pork meat import to Curaçao (source: UN Comtrade)

Year	*Pork meat import to Curaçao (ton/y)*
2013	*3027*
2014	*2939*
2015	*2886*
2016	*3068*
2017	*2732*

The value of imports in 2017 was USD 7.8 million (source: UN Comtrade), which amounts to an average of USD 2.85 / kg. The seasonal pattern is shown in Figure 4.

[8] http://www.intracen.org/ , visited on 10-10-2019

[9] https://wits.worldbank.org/wits/wits/witshelp/Content/Data_Retrieval/T/Intro/B2.Imports_Exports_and_Mirror.htm

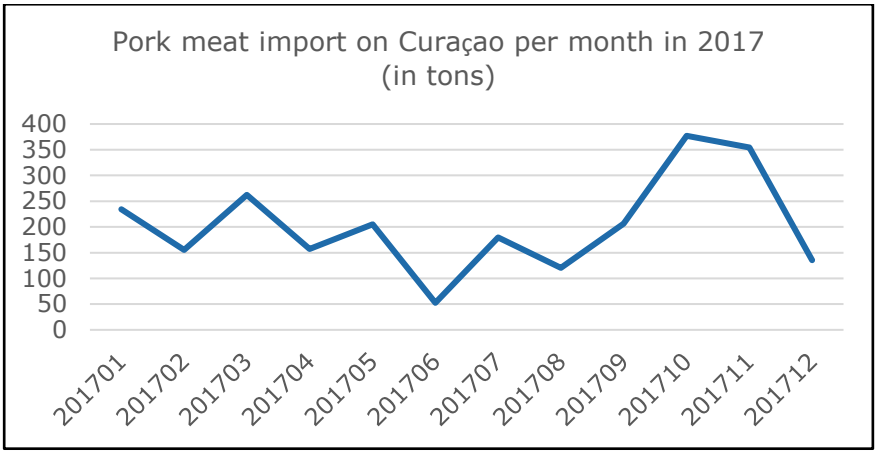


Figure 4. Seasonal pattern of pork imports in 2017 (source: UN Comtrade)

This shows that there is a peak in imports, especially at the end of the year. Later in this document it is shown that this may be related to the seasonal pattern of the tourist presence in Curaçao.

3.2 The pig sector on Curaçao

3.2.1 The size of the sector

The pig sector in Curaçao is small. There are around 40 farmers on the island, who together hold an estimated 3,000 pigs. Of these, 2,500 are destined for slaughter every year. This takes place at two public slaughterhouses, one at Parera and one at Barber. In these two slaughterhouses in Curaçao, mainly pigs, goats, sheep and cattle are slaughtered. The farmers remain the owners of the pig and not only pay for services such as the issue of meat sales permits and health certificates, but also for slaughter and inspection fees, and laboratory operations.

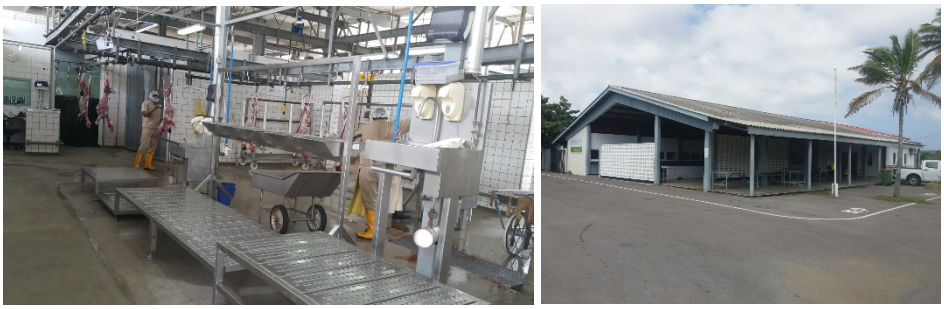


Figure 5. Slaughterhouse at Parera[10] (left), Barber[11] (right)

The live weight of a local pig is about 80kg, of which approximately 49 kg is meat[12], and with 2500 slaughterings per year, that means a local supply of 122.5 tonnes of pork. This means that the local supply on the market is only (122.5) / (122.5 + 2,165) = 5.4%.
About 5% of the local production of pork is sold in supermarkets on Curaçao[13]. The restaurants do not purchase locally produced pork.

[10] Source: Arnold Dwarkasing Head of Department CVO 12-2-2020
[11] Source: Arnold Dwarkasing Head of Department CVO 13-2-2020
[12] Measurements of 6 months in slaughterhouse on Curaçao, source Arnold Dwarkasing, Head of Department CVO (mail 7-10-2019)
[13] https://caribischnetwerk.ntr.nl/2014/12/11/varkenshouders-totaal-onwetend-over-dioxine/, visited on 25-9-2019

3.2.2 Food safety

In 2014 it was discovered that pig meat from Curaçao contains too high concentrations of the carcinogenic substance dioxin. Pig farmers were completely ignorant of dioxin[14]. A potential reason is ashes or emissions from burning plastics that come with food residues that they currently collect from retail and restaurants.

3.3 Eco-feed demand estimate

REFRESH (D5.5) [7] estimates that (for one estimated composition of food waste) per ton food waste about 3.3 pigs can be reared, yielding about 200 kg meat. Thus, for the current pork production volume, 122.5 tonnes, about 610 tonnes food waste would be needed. Since the food waste composition may significantly differ from the assumed composition by REFRESH, we estimate the needed volume of food waste between 500 and 1000 tonnes per year.

3.4 Pork consumption

Consumers in Curaçao can be divided into four groups:

a) The residents of Curaçao
b) The tourists that stay in accommodations
c) The cruise ship tourists
d) The day trippers

The estimate of demand per group is elaborated in the following subsections.

3.4.1 Estimate of pork demand from residents of Curaçao

According to the local stakeholders, a resident ate 91.5 kg of meat (beef, goat, sheep, pork, wild and poultry) in 2018, of which 13.5 kg was pork. Around 160.000 people live in Curaçao, so that the demand for pork for the local population in 2018 is estimated at 2,160 tonnes.

3.4.2 Analysis of pork demand by tourists

Tourism is one of the most important pillars in Curaçao's economy and as such has a strong influence on the demand for pork on the island.

[14] https://caribischnetwerk.ntr.nl/2018/10/17/slager-op-curacao-keurt-letterlijk-zijn-eigen-vlees/ visited on 25-9-2019

Figure 6. Cruise ships on Curaçao[15]

The number of tourists varies quite heavily. The number of tourist visits to Curaçao is recovering from a dip in 2016.

Table 1: Number of tourists per type on Curaçao from 2015 to 2018 [1]

Type tourists	2015	2016	2017	2018	2018%
Cruise	528,090	469,498	634,370	757,278	63%
Day trippers	38,202	32,993	24,208	20,689	2%
Stay	467,538	441,356	398,836	431,701	36%
Total	1,033,830	943,847	1,057,414	1,209,668	

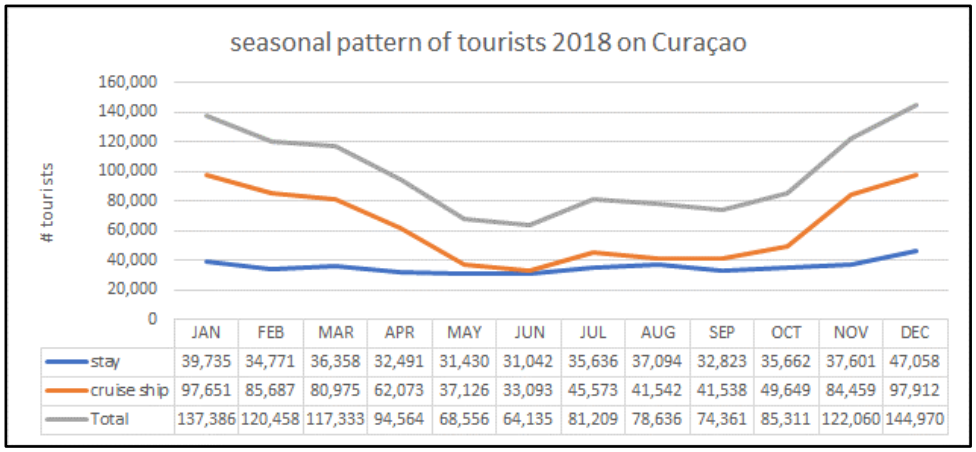
In order to get a more reliable picture of the demand for pork, both in terms of time and in terms of quantity, an in-depth analysis of the figures for 2018 is done. On the one hand, a distinction is made between the months of the year to see whether there is a seasonal pattern and on the other hand (where possible) according to the origin of the tourists, so that a differentiated amount of pork consumption can be used in the market analysis.

Seasonal pattern in tourist presence

Much of the pork supply on Curaçao is imported frozen, and because of investment costs in freezing utilities and the costs of energy for freezing, stock management is consciously handled. The storage capacity, the network, the price and market demand vary throughout the year, and the traders must always respond to this. The fluctuation in tourist offer throughout the year is therefore an important element in this sector. Of the three types of tourists, the residents and day trippers will mostly eat on the island, but that does not necessarily apply to cruise ship tourists.

The day trippers are only 2% and we can assume that they come from the Caribbean. The distribution over the months of this type is not known. The seasonal pattern of the visitors and cruise ship tourists is as follows (sources: [1], CBS[16] and www.curacaotouristboard.com[17]):

[15] https://www.knipselkrant-curacao.com/curacaonieuws-meer-cruiseschepen-en-passagiers-in-2018/, visited on 26-9-2019
[16] www.cbs.cw/website/tourism_3373/
[17] www.curacaotouristboard.com



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
stay	39,735	34,771	36,358	32,491	31,430	31,042	35,636	37,094	32,823	35,662	37,601	47,058
cruise ship	97,651	85,687	80,975	62,073	37,126	33,093	45,573	41,542	41,538	49,649	84,459	97,912
Total	137,386	120,458	117,333	94,564	68,556	64,135	81,209	78,636	74,361	85,311	122,060	144,970

Figure 7. Seasonal pattern of tourists entering per month in Curaçao

The pattern of the visitors can be called virtually constant throughout the year, while the cruise ship season shows a clear increase from November to March, with a peak around the turn of the year. In the months of January and December the island receives almost as many tourists as there are residents. We may assume that the tourists eat on the island. It is known from which region the tourists come and how many nights they stayed in 2018 (Figure 8).

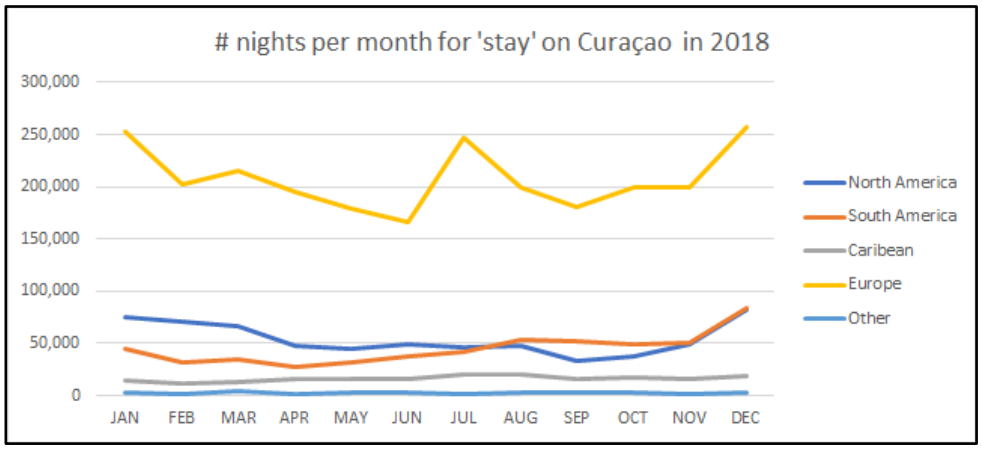


Figure 8. Number of nights per month that tourists have been to Curaçao in 2018

Just as at the total level, there is no major seasonal effect for this subdivision in terms of origin region. Only for European tourist visitors the summer and winter show an increase of around 20%.

Number of tourists per region of origin

In order to predict pork demand, we distinguish between the dietary habits of tourists, related to their origin. As a calculation basis we use the number of nights they have been present on Curaçao (Table 3).

Table 3: Number of nights that tourists from a certain region in 2018 stayed on Curaçao

North America	South America	Caribean	Europe	Other	Total
653,009	539,163	197,560	2,492,469	30,503	3,912,704

By combining the tourists number per origin with the average daily pork consumption, the demand was calculated on an annual basis. The most recent data, at the level at which the tourist information is known, comes from 2013[18] (Our World In Data = OWID), and uses FAO statistics. More recent data are available for various countries from the regions (OECD countries), but these do not cover all regions[19].

[18] https://ourworldindata.org/meat-and-seafood-production-consumption, visited on 20-9-2019
[19] https://stats.oecd.org/index.aspx?r=624299, visited on 20-9-2019

Table 4: Pork consumption per origin region

Source →	OWID	OECD	
consumption pork (kg/y)	2013	2013	2018
North America	27.16	20.95	22.34
South America	11.35	9.48	10.38
Europe	34.61	27.52	28.61
Caribean	11.04		

Through combining data from Table 4 with those in Table 3, the annual consumption of pork for stay-over tourists is estimated at 308 tonnes. Note that despite the fact that (according to Table 3) there are almost 4 million tourist days, annual consumption is much lower than that of the local population, because they are present all year round.

3.4.3 Pork demand from cruise ship tourists

In 2018 there were 757,278 cruise ship tourists. Assuming that they are all in Curaçao for one day and have an upper consumption limit of 34.61 kg / year (Table 4), the maximum demand from cruise ship tourists (757,278 x 34.61) / (365 x 1,000) = 72 tonnes. This may have been overestimated, because the highest values are taken from Table 3, and we do not know whether some tourists from the cruise ship eat on the boat.

3.4.4 Pork demand from daytrippers

There were 20,689 day trippers in 2018, who may be assumed to be from the Caribbean. With an estimate in terms of pork consumption of 11.04 kg / year, that means a total pork consumption for one year of (20.689 x 11.04) / (365 x 1000) = 0.6 tonnes.

3.4.5 Estimate of total pork demand on Curaçao

The total demand by the consumer groups addressed in the previous subsections is summarized in Table 5; these data are based on demand in 2018 and supply over 2017/2018 (best possible fit).

Table 5: Total supply and demand of pork on Curaçao

Demand (in tons/y)		Supply (in tons/y)	
The residents of Curaçao	2,160	Local production	122.5
The tourists that stay in accommodations	308	Import	2,165
The cruise ship tourists	72	Export	0
The daytrippers	0.6		
Total	2,540.6	Total	2,287.5

The demand of 2,540 tons per year requires 2,540,600/49 = 51,848 slaughtered pigs, whereas currently only 2,500 pigs are locally processed. Clearly, a very large market can be targeted if imports can be reduced, although this will remain limited given the size of the island.

3.5 Available food waste streams

In Curaçao there is one big player in the domain of waste management, which is Selikor NV. The main task of Selikor NV is servicing their largest customer, being the government of country Curaçao. The government buys as it were, a range of public services to Selikor NV and annually, to on the basis of the available government budget, the scope of these services is established. Typical services are:

- Household waste collection every week at around 70,000 households
- Collect monthly household bulky waste
- Keep main roads clean and residential areas

- Delete illegal dumps
- Remove carcasses from public roads
- Manage landfill

In addition to the work carried out by Selikor NV performed within the framework of the management agreement with the government, Selikor NV operates in the public sector as well on a commercial basis. The commercial business have activities in 2016 with 16.1% contributed to the total annual turnover of Selikor NV. Examples are (on demand):

- Waste collection and - transport of business waste at companies
- Sweeping work for private individuals
- Emptying of cesspools
- Picking up bulk and garden waste
- Collecting carcasses
- Garbage bags

Next to the waste it collects by themselves, Selikor also manages waste supplied by third parties.

Selikor operates three ways of waste management:
1. Recycling
2. Incineration
3. Landfill

Volumes are given in Table 6.
Recycling and incineration do not involve organic waste and are excluded from further analysis. Note that the share of recycling and incineration is relatively small compared to landfill [2].

Table 6: Waste flow destinations on Curaçao in 2017

Destinations of the waste	2017	
	tons	%
Landfill	158,852	92
Recycling	14,192	8
Incineration	78	0
Total	173,123	100

Landfill
Selikor NV manages, commissioned by the government, the only official and legal one landfill on the island, landfill Malpais. The facilities at the Malpais complex are not only used by Selikor NV but also by private individuals, companies as well households. Upon arrival all offered waste is weighted and registered per processing method in the application CLEAR (CLEAR: Container Emptying and Waste Registration). From the waste that comes in also the weight, type and supplier are registered.

The waste arriving at Malpais for landfill can be divided into two streams, one collected by Selikor NV and the other one supplied by private people or companies. A detailed split up is provided in

Table 7: Waste supply to landfill on Malpais in 2017 [2]

Landfill on Malpais in 2017		
1. Collected by Selikor	Tons	%
- Household waste	35,937	55
- Company waste	23,564	36
- Bulk household waste	1,894	3
- remediation waste from main roads	1,234	2
- sanitation waste from residential areas	0	0
- waste from illegal dumpsites	875	1
- Garden and bulk waste (paid)	814	1
- Non-recyclable waste from recycling center	1,089	2
Subtotal 1	65,406	100

2. Supplied by private people and companies		
- Diabaas (rock hard soil)	4	0
- Company waste	93,442	100
Subtotal 2	93,445	100
Total: subtotal 1+2	158,852	

There is no specific information on the composition of these waste flows. The food waste streams addressed in this research are part of the Company waste in Table 7, but not specified. As a consequence the amount of swill cannot be calculated from these data. An analysis of the flows done in 2003[20] pointed at 25% organic share in commercial waste. Based on that, the total amount of organic waste from Company sources is estimated at 25% x (23,564 + 93,442) = 29,252 ton per year. Be aware that this stream may contain many other sources of organic matter than retail/hotel/restaurant food waste, and thus is only an indicative absolute maximum.

3.6 Other developments

Given the island's limited size, it is relevant to look at other initiatives in the agricultural field, particularly in the livestock sector. Currently, a foreign investor is busy starting up meat production in Curaçao. A plan has been launched for a Concentrated Animal Feeding Operation (Cafo) with a thousand cows or bulls is coming to Bándariba, near Dam Pretu near Chincho, supported by a letter of intent signed by five ministers[21].

3.7 Conclusions from market data analysis

The current pork supply is largely depending on import; market volume is large enough to accommodate growth of the production volumes. The feed demand for rearing the current pig population, assuming their feed demand would fully be based on food waste, could be fed with about 500 to 1000 tonnes food waste per year. Fulfilling the complete pork demand on Curaçao by fully-Eco-feed reared pigs would require 15,000 to 30,000 tonnes food waste.
Data about waste are insufficiently specified to estimate total volume of food waste from retail/hotels/restaurants.

[20] 'Initial waste analysis', received by mail from Arnold Dwarkasing on 8-10-2019
[21] Antilliaans Dagblad, 31-12-2018, pag. 8, https://docplayer.nl/114588565-Dit-was-2018-het-antilliaans-dagblad-wenst-u-een-nieuwsgierig-2019.html. Gezien 26-9-2019.

4 Stakeholder input

In a field trip (October 2019) data and attitude from a broad set of stakeholders were collected: government, retailers, hotels/restaurants, farmers, waste collectors and a waste manager.

4.1 Stakeholder consultations

Government/Kabinet (Alvin Daal)

- The government is interested in increasing circularity, innovation, job development, and reduction of dependency on import. The concept of Eco-feed fits very well in that.
- Safety is priority, and could be used as a criterion for livestock farming permissions.

Supermarkets: Mangusa (Gilberto Gonsalves) and Goisco (Joel da Silva Gois, Fabian Ortega)

- *Food waste generation:* In retail different food waste streams are generated: reject (not suitable for sale) and cut offs of convenient foods production. The retail sector is growing. Indicative volume: "a few drums per day" per retail market (estimated at 50 to 100 kg per day).
- *Current disposal:* Fruit and vegetables and some prepared food waste is separately collected from other food waste. The fruit and vegetable waste is mostly collected by pig farmers; the rest is collected by a waste collection company (destination: landfill).
- Supermarkets stakeholders would gladly provide all food waste to an Eco-feed company.

Hotels: Sunscape all-inclusive

- The number of all-inclusive hotels (currently 4) is growing on Curaçao.
- The all-inclusive formula induces relatively large amounts of food waste.
- The corporates aim for sustainable development; more sustainable use of food waste can contribute to that.
- Waste from kitchens and consumers is collected separately; this way of working could be extended to more specified separation of food waste streams. Currently the waste is collected by a waste collection company, destined to landfill.
- Typical volume: multiple waste bins per day per hotel (estimate: 200kg).

Restaurants (McDonald's, Hucor Holding (Kentucky, Pizza Hut, Subway), Scampies)

- These restaurant formulas have dozens of restaurants on Curaçao.
- Some collect their fruit and vegetable waste separately from other waste; this fruit and vegetable waste is irregularly collected by pig farmers. Some of these initiatives were stopped because of either quality issues with the pig feed or unpredictable behaviour of the collecting pig farmer.
- Other food wastes are collected by a waste collection company (destination: landfill).

Pig farmers

- Only small volumes of pig feed are available on Curaçao. A small fraction is based on waste from restaurants, hotels and retail; some farmers have access to specific food processing side streams; the rest is imported feed concentrates. One farmer explained that he uses feed concentrates for rearing pigs and food waste from restaurants for sows. If he could get access to larger volumes of food waste, he would also include it in the diet for the rearing pigs.
- Current price for feed concentrates is almost 1 Antillean guilder (ANG) per kg, which equals around 0,51 Euro[22].
- Collected food waste from restaurants/retail is not always adequate, dependent on the waste separation. Continuity is considered very important.

[22] https://www1.oanda.com/currency/converter/ visited on 14 feb.

Waste collection companies (Maduro Shipping and Dijk Transport)

- These companies serve the management of waste from cruise ships, amongst which food waste.
- New cruise ships have waste incineration facilities on board, and do not supply food waste. Older ships (about 50%) supply food waste in frozen form.
- Typical volume 30 to 50 tonnes per month.

Waste management company (Selikor)

- Selikor collects municipal waste and manages these as well as other supplied wastes (see section 3.5).
- Selikor aims to further extend circular valorisation of the currently considered waste streams.
- Current tariff for landfill is 30 Antillean guilder per ton.
- Sustainability impact (induced greenhouse gas emissions) is not a driver for innovation, but circularity and limited capacity are.
- Selikor is interested in developing an Eco-feed processing line. Selikor actually decided to submit a grant proposal to the European Development Fund (EDF) for making the next steps in the realization of an Eco-feed plant.

Figure 9. Interactions with stakeholders

4.2 Reflections on the stakeholder consultations

All stakeholders have a very positive attitude toward Eco-feed.

Currently part of the food waste from the hotel, restaurant and retail organisations are used for animal feed. However, this use is largely limited to fruits and vegetables which have low energy and protein content; the energy-rich and protein waste fractions largely go to landfilling, which means that the most interesting part is wasted. Moreover the utilized waste streams are not certified animal-protein free, so this may induce safety hazards.

The pig feed supply chain is currently not institutionalized. Many farmers have their own sources of feed, often with irregular supply, and combine that with expensive feed concentrates. A more continuous and quality-oriented supply would benefit all. An Eco-feed processing plant could fill that gap.

Based on the indicative food waste volume estimates, the total availability is estimated at order-of-magnitude 1000 tonnes per year. This volume fits in the pig farmers' feed demand, as estimated in section 3.3; it is expected that the pig production volume may increase when this feed will be available.

The positive attitude and expectations are substantiated by the EDF proposal for developing an Eco-feed plant by Selikor.

5 Reflection Eco-feed chain Curaçao

Techno-economic scaling evaluations by EU-REFRESH suggest that under European market conditions, medium-sized treatment plants can be commercially viable. The smaller volumes of food waste in Curacao will drive up processing costs. These higher costs, however, may still result in a positive business case because reference feed prices in Curacao are significantly higher than in Europe. Furthermore, institutional financial support (such as EDF) for setting up a treatment plant, would result in the investment costs' contribution to the total costs being reduced. Altogether it is expected that the intended business will be economically viable for safe feed supply; a detailed financial analysis should be part of the follow-up project.

5.1 Cost-benefit estimate

Costs and benefits were derived with the Eco-feed cost model from REFRESH (D6.11)[5] and engineering estimates of variable costs.

Based on engineering cost price estimation for the process shown in Figure 1 for the intended scale (1000 tons food waste per year, 12 hours operation per day, 6 days per week) and connected services we come to the following estimates for required fixed expenses (1 ANG ≈ €0.50):

Process Equipment Cost	k€ 175	350,000 ANG
InSide Battery Limits costs	k€ 490	980,000 ANG
Total fixed capital costs CAPEX	*k€ 890*	*1,780,000 ANG*
Collection vehicle	k€ 250	500,000 ANG
Total CAPEX + vehicle	*k€ 1140*	*2,280,000 ANG*

Operational costs estimates (per year):

Maintenance	k€ 36	72,000 ANG
Labour related	k€ 80	160,000 ANG
Consumables	k€ 4	8,000 ANG
Water	k€ 2	4,000 ANG
Thermal energy	k€ 5	10,000 ANG
Electricity	k€ 6	12,000 ANG
Transport	k€ 24	48,000 ANG
Raw material (prevented landfill costs)	k€ -15	-30,000 ANG
Total OPEX	*k€ 142*	*284,000 ANG*

The feed selling price is not yet determined (actual appreciation will be highly decisive; also the development of a new slaughter facility, currently in planning, will be essential for actual price level), but first estimates are positive.

5.2 Steps toward development of Eco-feed chain on Curaçao

This report presents a high-over feasibly analysis for an Eco-feed chain on Curaçao. For actual development, however, more thorough analysis will be needed:

- *Safety.* As argued in REFRESH (D6.7)[4] threats of pathogens and mycotoxins can be controlled through adequate quality-oriented setup of the collection chain and processing. More detailed knowledge will be developed in a dedicated PPP research project by Wageningen Research starting in 2020. Other threats may come from residues of chemicals (may for instance be found in higher concentrations on peel than on the actual products consumed by humans); to be analysed.

- *Eco-feed nutritional quality:* This may significantly deviate from the composition assumed by REFRESH (6.7)[4]. With an eye on the tourists background, the nutritional value is expected somewhat higher, which would justify a firm price level.
- *Logistics:* Daily collection will be necessary for safety reasons; how to organize this efficiently (given the relatively small volumes).
- *Processing:* Also with an eye on the small volume, cost-efficiency measures should be considered (especially with respect to labor costs).
- *Quality certifications:* Curaçao legislation appears not very demanding, but a basic certification and verification will be necessary for general acceptance of the system and products.

5.3 Reflection on environmental aspects

The concept of Eco-feed converts a waste stream to animal feed, a valuable resource. A waste stream that is currently largely landfilled, which is not environmental-friendly and leads to a waste of valuable nutrients with negative environmental impacts (like methane production, a serious greenhouse gas). The concept fits in recent views with respect to need of more circular solutions and reduction of inputs need (feed). Since the processing requires relatively small resources and utilities, and only minimal logistics are needed, Eco-feed is very attractive from an environmental point of view.

6 Results and next steps

Figure 10 shows an overview of the main outcome of this study. The study revealed that Eco-feed fits very well on Curaçao, with relatively favourable food waste availability, high interest by pig farmers and strong demand for pork.

Estimated volumes of available food waste streams are quite well balanced with current pig feed need. With an eye on the relatively small volume, the cost price of Eco-feed will be firm.

However, also the reference feed (imported) is relatively expensive. All stakeholders consulted were very positive about the idea.

Follow-up of this study was started through an EDF grant proposal submitted by Selikor (aimed at developing the intended plant on Curaçao).

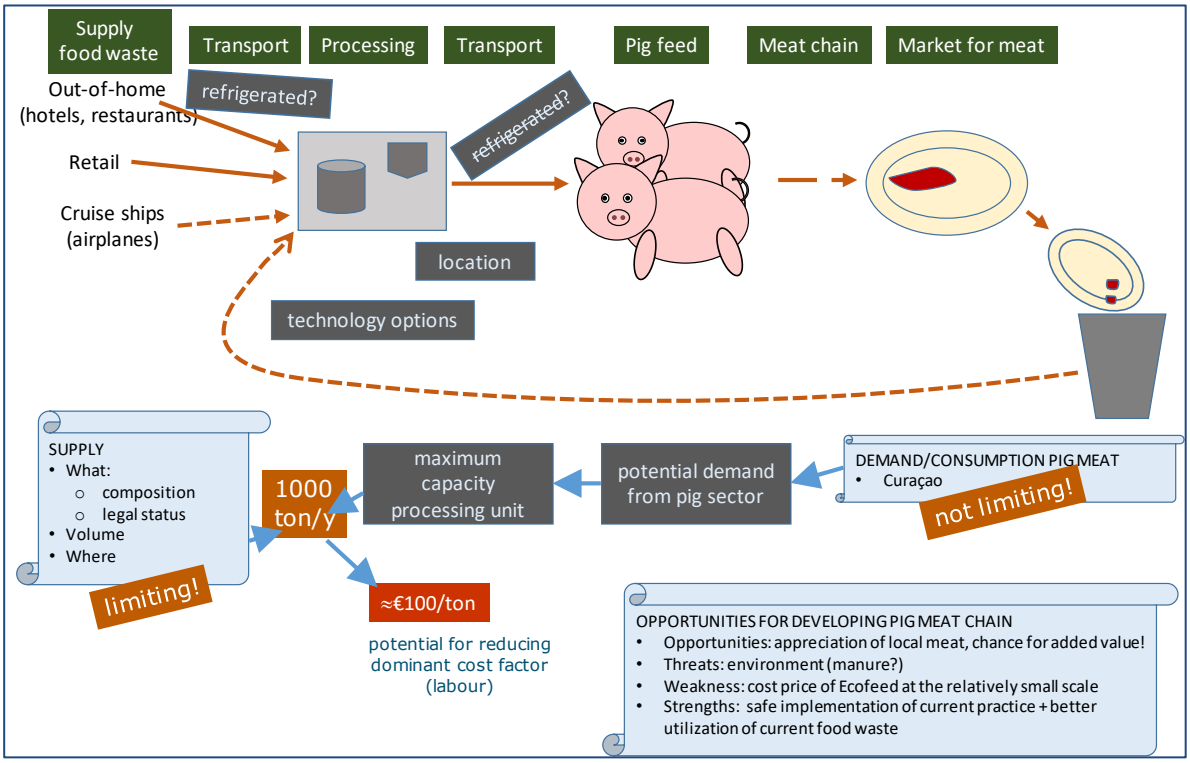


Figure 10. Summarizing outcomes of the study

7 References

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To explore the potential of nature to improve the quality of life

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Report 2023

The mission of Wageningen University and Research is "To explore the potential of nature to improve the quality of life". Under the banner Wageningen University & Research, Wageningen University and the specialised research institutes of the Wageningen Research Foundation have joined forces in contributing to finding solutions to important questions in the domain of healthy food and living environment. With its roughly 30 branches, 5,000 employees and 12,000 students, Wageningen University & Research is one of the leading organisations in its domain. The unique Wageningen approach lies in its integrated approach to issues and the collaboration between different disciplines.