WEST AFRICA FAIR FRUIT

Summary of Studies on Environmental Performance of Fresh Pineapple Produced in Ghana for Export to Europe

MARCH, 2011

ACKNOWLEDGEMENTS

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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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Taste Developing Fair-Trade Markets

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Disclaimer: The findings, conclusions and opinions of this report are wholly those of ADAS and WAFF and not those of any of the funding organizations

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LIST OF ABBREVIATIONS

LCA - Life Cycle Assessment (LCA

GWP - Global Warming Potential

WAFF - West Africa Fair Fruit

MOAP - Market Oriented Agric Programme

GIZ - Deutsche Gesellschaft für Internationale Zusammenarbeit

GWP - Global Warming Potential

RDC - Regional Distribution Centre

GHG - Green House Gas

1. BACKGROUND / INTRODUCTION

OBJECTIVES

The objective of the studies summarized here was to analyze the environmental performance of pineapple exported from Ghana and to understand how performance can be improved. A central part of this work was the inaugural application in Ghana of the voluntary standard PAS2050 on fresh Ghana pineapple. There were five specific objectives for this study and they are as follows:

1. **Objective One:** Assessment of the carbon-footprint (global warming potential) of fresh pineapple, from farm production to an importers distribution warehouse in the Netherlands. Using the international standard PAS2050.

2. **Objective Two**: Review potential environmental impacts from pineapple production, other than global warming potential (GWP), using information from published sources.

3. **Objective Three:** In partnership with the two businesses involved, develop an emissions reduction plan, taking into account the context of business operation, costs and constraints.

4. **Objective Four:** Estimate the emissions for alternative pineapple products exported from Ghana and consumed in Europe. Including, whole fruit by sea and by air, cut fruit by air, de-crowned fruit by sea, ascetic NFC juice by sea, dried pineapple by sea.

5. **Objective Five:** Increase the profile of the environmental sustainability issues covered in the study through exchanges with Industry stakeholders and partners.

Objective 1 to 4 are documented in separate reports, some of the information within these is confidential to the businesses involved. This summary is a compilation of these four sub-studies.

Objective 5 is an on-going process. There are discussions with various organizations on how the results of this work may be used within Ghana alone, regionally or within an international programme.

2. OBJECTIVE ONE: ASSESS THE CARBON FOOTPRINT OF FRESH PINEAPPLE

The carbon footprint of a product can be referred to the life cycle greenhouse gas (GHG) emissions or the global warming potential (GWP). In this study life cycle emissions of GHG were assessed and expressed in units of carbon dioxide equivalent (CO2e)[1]. The assessment was carried out using PAS2050; which is a specification for the assessment of the life cycle greenhouse gas emissions applicable to any good or service (See: www.bsi-global.com/en/Standards-and-Publications). PAS2050 was created in 2009 to be an internationally available standard. The assessment was made using the UK Carbon Trust's spreadsheet tool called 'Footprint Expert™' and related databases. The assessment used **primary data** from a value chain for MD2 pineapple produced and traded by two businesses: a producer of pineapples in Ghana and an importer in the Netherlands. The assessment is termed a business-to-business assessment. This included production of fruit in Ghana, export by sea, up to the point where the fruit is ready for dispatch from the warehouse in The Netherlands.

The second stage of the product life beyond the importers warehouse was done using **secondary data.** This study 'followed' the fruit to a hypothetical consumer in a town in southern Finland, with a logistic chain via a receiving supermarket appropriate for that location. This desk study followed PAS 2050 rules as far as possible. Data used in this assessment were for the period October 2009 to October 2010. Data were publicly available, or were primary data from industry partners, or were experts' estimates, e.g. from employees of industry partners, consultants etc. The assessment process was divided into a series of stages. The stages were:

- **Farm** – all processes from planting to harvest;
- **Pack house** – all processes from harvest to the point where fruit are ready to leave the farm;
- **Export to the importers warehouse** – all transport and processes from the farm to the point where the fruit are ready to leave the importers warehouse;
- **Distribution to the Retail Distribution Centre** – all transport and storage as far as the Regional Distribution Centre (RDC) of the local supermarket in Finland;
- **Retail** – all transport, storage and disposal of waste from the RDC up to the point of purchase; and
- **Consumption & end of life fate** – all emissions arising from the storage and disposal of fruit in a consumers' home.

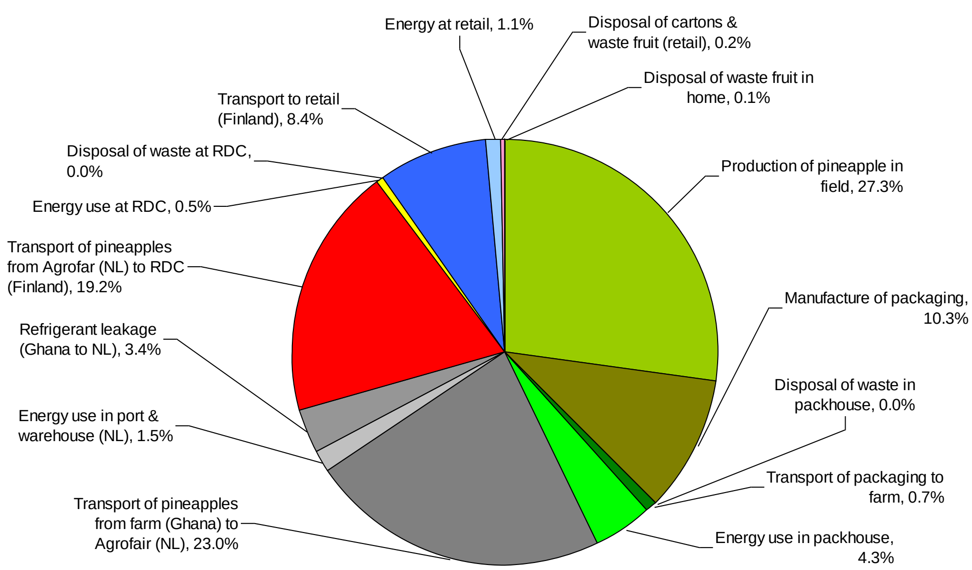
Once the PAS2050 was complete the assessment was submitted for independent verification by the Carbon Trust, which is the certification body authorized to issue certification for PAS2050 assessments. The verification (or gap analysis) found that the assessment was good, with only a small number of clarifications needed to allow a certificate to be issued.

Results

[1] Gases such as methane, nitrous oxide or leaked refrigerants have much higher global warming potential (GWP) than CO2. Methane has a GWP 21 times higher than CO2, and so the GWP of 1 kg of methane is 21 kg CO2e.

Total life cycle emissions (primary production to end use and waste disposal) were calculated per 1 kg whole fruit (as purchased by the consumer) and per 100 g portion of edible fruit (see Figure 1).

- Carbon footprint = **0.954** kg CO_2e per **1.0** kg of whole fruit purchased by consumer
- Carbon footprint = **191** grams per **100** gram edible portion



Green colours	**Farm & pack house emissions**
Greys	**Transport to and storage at importer's warehouse**
Red	**Transport to and storage at RDC in Helsinki**
Blues	**Transport to and storage at Retail shop**
Pink	**End use**

Fig 1: Emissions from a kilogram of fresh pineapple (emissions from production to consumption including disposal of waste fruit = 191 g per 100 g edible fruit)

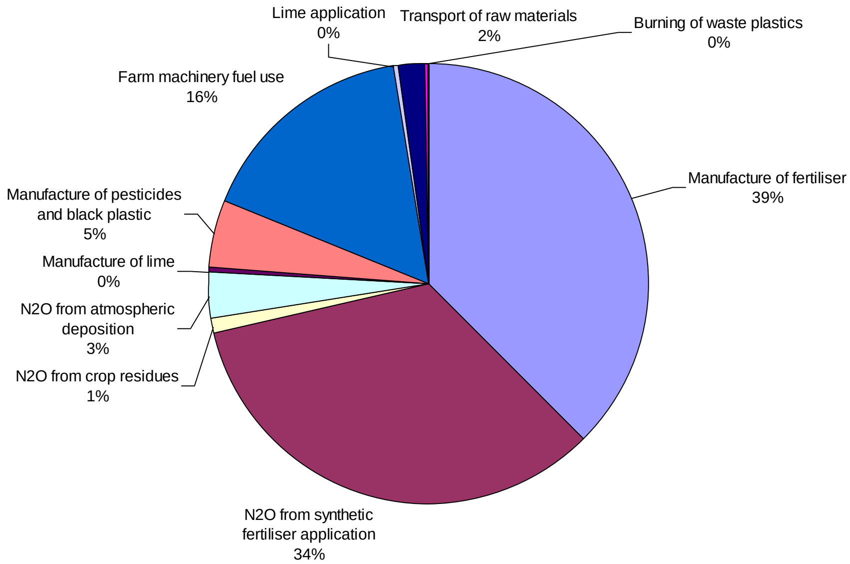


Fig 2: Farm production (excluding packing) = 0.26 kg CO2e per kg of fruit entering the pack-house (27.3% of whole lifecycle emissions); or 52 grams CO2e per 100 g of edible fruit flesh

The analysis of farm production shows that, the manufacture and use of fertilizers (including fertilizer derived N2O emissions from soils) contribute 73% of total farm emissions. Almost all fertilizer related emissions are due to nitrogen fertilizer. The other 'hotspot' is fuel use (16%). These two hotspots account for 89% of farm emissions and should therefore be the main target for any mitigation efforts.

This analysis does not include any carbon losses from the soil or ecosystem or potential carbon sequestration, as the rules of PAS2050 mean that these not need to be included. There are two possible sources of CO2e losses due to land use change:

- Changes in soil carbon content from soil after it comes into cultivation from 1) Erosion 2) decay or accumulation of organic matter; decay will accelerate with intensive cultivation, but with good soil management and rapid crop growth soil carbon might equally be stable or increase.
- Changes in carbon due to land-use conversion from its pre-pineapple farm use. PAS2050 only require post 1990 conversion to be included. The land in this study was converted after 1990, but at that time it was already farmland; had it been converted from tropical forest then this might have led to considerable emissions being attributed to this cause.

There is further discussion of land-use change and soil carbon under Objective Two.

Table 1 shows in more detail emissions for different stages of the life cycle from primary production (farm and farm raw materials) to the end of the farm stage (including the pack house), to the importers warehouse, to the RDC in Finland, and for the retailing consumption and disposal of waste.

Table 1: Emissions of fresh pineapple produced in Ghana per kg of whole fruit, per 100 grams of edible fruit and as a percentage of the whole lifecycle emissions.

Stage	Emissions for 1 kg whole pineapple kg CO_2e / kg	% of total life cycle emissions	Emissions per 100g ready to eat fruit g CO_2e / 100 g
Farm			
Production of pineapples (in field)	0.26	27.30%	52
Manufacture of packaging	0.098	10.30%	19.7
Disposal of waste in pack house	0	0.00%	0
Transport of packaging to farm	0.007	0.70%	1.4
Energy use in pack house	0.041	4.30%	8.3
Total farm emissions (including packing)	**0.407**	**42.60%**	**81.4**
Export to Europe			
Transport of pineapples from farm to warehouse	0.22	23.00%	43.9
Energy use (in port & warehouse)	0.014	1.50%	2.9
Refrigerant leakage from containers	0.032	3.40%	6.5
Total up to importers warehouse	**0.673**	**70.50%**	**134.7**
Transport to RDC (Finland)			
Transport (importer's warehouse to Finland)	0.183	19.20%	36.6
Energy use at RDC	0.005	0.50%	1
Disposal of waste at RDC	0	0.00%	0
Total, up to Retail Distribution Centre	**0.861**	**90.20%**	**172.2**
Retail, home use & disposal			
Transport to retail	0.08	8.40%	16
Energy use at retail	0.01	1.10%	2.1
Disposal of waste at retail	0.002	0.20%	0.4
Disposal of waste at in home	0.001	0.10%	0.2
Total for whole life cycle	**0.954**	**100%**	**190.8**

There is no other published data on pineapple carbon footprints that we are aware of, however the study team did see a confidential draft of a similar study in another country that had broadly similar results. The expectation of the team working on this study is that most fresh MD2 supply chains will have similar profiles with similar 'hotspots'.

To put these pineapple emissions calculations in a broader context, GHG emissions associated with some other foods are shown in Table 2 below.

Table 2: Emissions of fresh pineapple from Ghana retailed in Europe compared to other food products.

	Calories	Carbohydrate (%)	Fats (%)	Protein (%)	g CO_2e / 100 g portion	g CO_2e / Calorie
Retailed products						
Pineapple (consumed in Finland)	50	94	2	4	191	3.8
Bread as retailed in UK	266	78	11	11	163	0.6
Milk (semi skimmed, as retailed in UK)	50	39	35	26	140	2.8
Apple juice at farm shop in UK	46	---------- No data ---------			160	3.5
Products before retail stage						
Pineapple at importers warehouse, NL	50	94	2	4	135	2.7
Apple at farm gate, UK	52	95	3	2	6.6	0.1
Chicken meat (raw) at slaughterhouse in UK	319	0	81	19	370	1.2
Beef (trimmed lean, raw) at slaughterhouse in UK	142	0	36	64	3000	21.1

This data suggests that pineapple emissions are relatively high, but largely due to off-farm emissions especially due to refrigerated transport and storage. However, they are still not among the highest polluters and probably are no better or worse than many refrigerated tropical fresh products entering Europe by sea. All air-freighted fresh products are likely to be more polluting.

3. OBJECTIVE TWO: REVIEW OF ENVIRONMENTAL IMPACTS

(Other than greenhouse gas emissions)

The purpose of Objective Two is to verify which impacts, other than GHG emissions and global warming potential, are significant and warrant further consideration. Reviewing all impacts is in keeping with the approach of Life Cycle Assessment (LCA) which is a widely used methodology used for assessing environmental impacts of value-chains. This study reviewed evidence collected from three sources:

- Scientific publications and reports in peer reviewed journals
- 'Grey literature' sources (websites, unpublished company information and presentations, unpublished consultants reports) and the media.
- Observation of farm practices in Ghana.

The impact categories covered in the search were:

- Pesticide use/ecotoxicity
- Abiotic resource use
- Acidification potential
- Eutrophication[2] potential
- Land use (conversion)
- Water use
- Soil erosion

Results

There was a scarcity of literature specific to pineapple and in particular to pineapple in West Africa in some impact categories. For pesticide use/ecotoxicity abiotic resource use, acidification potential, eutrophication potential and water use, there were few studies relating specifically to pineapple production. However, inferences were drawn from knowledge of the farming activities and the impacts general to crop production.

The impact category, soil erosion and loss of soil organic matter, was of particular interest because erosion is a problem in some West African pineapple fields and is widely reported as a major category from other regions of the World; however, this is not a standard environmental impact category used in life cycle assessment (LCA). Soil erosion and loss of soil organic matter can have many environmental and commercial impacts. Soil erosion pollutes water, and wastes nutrients. On the other hand, protecting soils and increasing soil organic matter is consistent with good farm and business practice.

[2] Eutrophication: the addition of substances, such as nitrates and phosphates (from fertilizers), sewage, soil organic matter, to an aquatic system (rivers, streams, lakes, ponds, seas). It also refers to the increase of phytoplankton in a water body. Negative environmental effects include the depletion of oxygen in the water, which induces reductions in specific fish and other animal populations. Green water of farm dams may be a sign of eutrophication due to fertilizer and soil run-off.

The overall conclusion from this study was that soil erosion is an impact category which should be a priority for mitigation in places where it occurs.

A second tier of priorities are for three other impact categories for which there is little data, but for which there could be significant in Ghana:

- pesticide use/ecotoxicity,
- land-use change and
- eutrophication

Pesticide use/ecotoxicity refers to the volume, concentration, toxicity and ecological impact of pesticides from the pineapple industry.

Land-use refers to impacts arising from the conversion of land. Land-use is not addressed strongly by PAS2050 and there may be additional GHG emissions arising from changes (e.g. losses of carbon if forest is converted to farmland). Land-use practices can also increase soil carbon. Changes in land-use have knock on effects on other impact areas such as biodiversity, watershed, flood protection as well as social impacts if access to land for local communities is affected.

Eutrophication is related to soil erosion, excessive run-off; causing soil loss and removes fertilizer and pesticides. Green water in farm dams is an indication of eutrophication. Thorough run-off of fertilizer, organic matter or pesticides into streams and rivers in the pineapple zone has never been measured for export pineapple fields in Ghana (as far as the study team is aware).

Recommendations for action are shown in Table 3 Concerns may be different from farm to farm; depending on the type of system used (e.g. an organic certified farm may not have a problem with ecotoxicity, though it could have a problem with soil erosion and high GHG emissions per kg if fruit is air-freighted). Table 3 reflects the opinion of the consultants on levels of concern for different impact categories and suggests action that could be considered according to the concern levels:

Table 3: Scoring of different environmental impact areas according to perceived concern level, potential action and responsibilities for fresh pineapple production in Ghana

Impact area	Concern level	Action	Responsible organization(s)
GHG emissions and climate change	1	Emissions reduction planning and implementation, based around the already completed PAS2050 (see separate report on GHG emissions improvement plan). Explore link of emissions reduction to marketing opportunities.	Farm and other chain businesses.
Soil erosion	1	Develop package of measures for erosion control and soil quality improvement. Move quickly to farm trials and whole-farm action planning and industry wide support.	Farms, industry associations, sector government agencies, donors.
Pesticide use / ecotoxicity	2	Further evaluation may be required. Focus should be on decreasing impacts rather than volume of products used. Planning to reduce pesticide use where this is positive or neutral for business performance should be researched.	Farms, industry associations, sector government agencies, donors.
Land use	2	Needs review of options for controlling land-use change. Interaction with soil erosion and soil carbon sequestration (e.g. potential to recommend land certain classes of land are not converted to pineapple production.	Farms, Industry associations, government agencies NGO/donor support network.
Eutrophication potential	2	Needs quantification of issue. Any action would be linked to soil erosion and degradation (see above). Actions for erosion control will also have benefits for water quality.	Farms, industry associations, government agencies, NGO/donor support network.
Acidification potential	3	No action necessary at this time.	-
Abiotic resource use	4	No action necessary at this time.	-
Water use	4	No action necessary at this time.	-

<u>Concerns</u>

1. Significant concern over impacts warranting mitigation
2. Concerns warranting further review and possible action
3. Some concerns, but not warranting action except observation
4. No current concerns

4. OBJECTIVE THREE: EMISSIONS IMPROVEMENT PLANNING

Objective One of this study calculated the GHG emissions from the fresh pineapple export chain. Objective Three focuses on defining emissions 'hotspots and potential action to reduce emissions within these.

Possible actions to reduce emissions were scored according to four categories:
1. Improvement potential,
2. Complexity,
3. Timescale, and
4. Cost / economic viability.

The plan was prepared by consultants from ADAS and WAFF and discussed with the two businesses that were the subjects of this study, the producing farm and the importer. This report summarizes some of the results of the consultation and discussions as well as incorporating additional information from new sources.

Results are shown in table 4.

Table 4: Greenhouse gas emission hotspots for fresh pineapple by boat to Europe.

Greenhouse gas emission hotspots	**Percentage of life cycle emissions**
1. Manufacture of fertilizer (mainly due to nitrogen fertilizer)	10.3%
2. Emissions of N_2O from soil (due to Nitrogen fertilizer)	9.2%
3. Farm fuel and energy use	4.5%
4. Cardboard carton manufacture	8.4%
5. Processing energy in the pack-house, mainly for cooling (off-grid/using generator)	4.3%
6. Refrigerated shipping by boat	24.8%
7. Energy use in port and cold storage	1.5%
8. Road transport in refrigerated trucks to the Retail Distribution Centre	19.2
9. Road transport in refrigerated trucks from the RDC to the point of final sale	8.4%
10. Disposal of the cardboard carton	0.2%
11. Disposal of waste peel, tops and core in the consumers home	0.1%
Total	**90.8%**

Overall we estimate that saving in GHG emissions of over 20% are believed possible by the main actors in the chain (the farm and the importer). The major impact of refrigerated shipping is one which is in the hands of the shipping companies and so is hard to change.

There are four key areas for improvement:

1. **Nitrogen fertilizers – up to 10% saving in lifecycle emissions.**
   One of the key contributions to GHG emissions from production of pineapples on the farm is the use of nitrogen fertilizers. A large amount of emissions are released in the manufacture of these fertilizers, but in addition N_2O is released as a result of its application. N_2O and this is a potent greenhouse gas. Roughly 20% of whole life-cycle emissions are due to Nitrogen fertilizer and it is believed that over time 50% reductions from nitrogen could be achievable without reducing yield.

   If ways of reducing fertilizer applications, without negatively affecting yields, can be identified and tested there is the potential to significantly reduce the cost of production of pineapple.

   There are existing and newly emerging technologies that are becoming available to improve fertilizer use efficiency. For example:

   - Urease inhibitors (e.g. Agrotain) prevent volatilization of Urea. Urea is a major source of N in the pineapple industry in West Africa and it is one of the most inefficient sources. Urease inhibitors are being tested on other crops (no known published data yet for pineapple).
   - Biological nitrogen fixation:
     - Preparations of freeze-dried nitrogen fixing bacteria are being tested on a range of crops in many cases these can substitute 25-50% of nitrogen from fertilizer (e.g. Twin-N). These have been tested on pineapple in Australia with some positive results. However, these preparations are living products and so are difficult to use and difficult to assess.
     - Planting in rotation with *Mucuna pruriens* as a cover crop is practiced by some commercial pineapple export farms in Ghana. Many more farms have tried *Mucuna* but decided not to grow it because it is difficult to clear and suppress. Research has indicated that the effectiveness of *mucuna*, in West Africa is enhanced by inoculation with mycorrhizal fungi, and *rhizobia;* when growing conditions are optimal a *mucuna* crop provides an equivalent of up to 120 kg N kg ha^{-1} of N fertilizer in 12 weeks of growth[3]. In addition recent (published) research by WAFF shows how *mucuna* is very active in heavily suppressing nematodes, so benefits are multiple. It is therefore probable that has more potential than many farms realize.
   - Another approach to reduced emissions is to invest in agronomic trails on soil and plant nutrition management. Pineapple farms tend to use a lot of fertilizer and there has been relatively little investment in research by the industry. On a World scale most research on pineapple is by multinational companies and so there is relatively little data available to independent farms. It would be expected that careful trials would indicate how to optimize

[3] Sanginga N et al .; Plant and soil 1996, vol. 179, n°1, pp. 119-129

fertilizer use and application and how to integrate fertilizer application with other methods of managing N (e.g. using bio-fixation etc).

- Recycling nitrogen, other nutrients and organic matter
    - Some farms do not incorporate old mother plants back into the soil and these contain significant amounts of Nitrogen as well as a lot of organic matter and other nutrients.

Table 5: Data from Smooth Cayenne grown in conventional commercial farms (adapted from Bartholomew, 2003)

Kg in crop residue			**Kg in fruit and crown**			**Kg in residue + fruit + crown**		
	min	max		Min	Max		Min	max
N	201	282	N	254	338	N	456	620
K	158	425	K	298	607	K	456	1031
P	19	25	P	33	25	P	51	50
Ca	68	198	Ca	173	212	Ca	241	411
Mg	40	90	Mg	131	216	Mg	172	306

Incorporating old plants well and supplying organic matter from sources with a high carbon: nitrogen ratio (e.g. cocoa factories) can also supply nitrogen that quickly becomes available to the pineapple crop. This approach is expensive but has other benefits such as suppression of nematodes and improving soil health generally.

- Some commercial export farms in Ghana have been experimenting with cocoa factory waste (the hulls, or skin of the roasted cocoa beans) this contains significant amounts of nitrogen Nitrogen: carbon ratio and so the nitrogen becomes available easily. Results from WAFF trails have shown how this too can have a remarkable effect on reducing nematodes in pineapple fields and so this approach to recycling nutrients has other multiple benefits. There is increased interest on a world scale of using organic waste from industry and urban organic waste as an input for sustainable commercial agriculture.

- Manufacture of fertilizer results in substantial GHG emissions. There is also significant variation in the emissions from different manufacturers and it may be that in future fertilizer will be labeled and farms can choose to buy fertilizer from the most energy efficient manufacturers (which might well be the lowest cost).
    - Global average = 36.9 Giga Joules per tonne NH_3
    - Average for members of European Fertilizer Manufacturers Association = 34.7 Giga Joules per tonne NH_3
    - Best Available Technology = 31.8 Giga Joules per tonne NH_3

There is a choice of types of fertilizers with different emission levels in manufacture and uptake and also very different costs. For example, calcium ammonium phosphate is more expensive than urea but less of the N tends to be wasted. Managing nitrogen for optimal efficiency is difficult, but is areas that managers can focus on to reduce both costs and emissions[4]. However, this is an area that would be easier to recommend if the industry was supported by clear information and relevant farm-based research on fertilizer.

2. **Fuel and energy use on farms – up to 2.0% of life cycle emissions reductions possible**
   This case study is for a farm not yet connected to the Ghana power grid; farms connected to the grid benefit from power that is mainly derived from hydro-power, and so has a lower GHG emissions factor. Fuel consumption on farms can be reduced in many ways: e.g. training drivers, ensuring optimal tire pressure, good maintenance of tractors and implements, imposing speed restriction. Tractor manufacturers are now starting to rate their machines according to fuel efficiency and a new generation of machine engines (e.g. hybrids) are being developed which will be available in future. There are proposals for low interest loans from international institutions funding business development in Africa to be preferentially available for low emissions equipment.

3. **Packaging - up to 4% possible**
   Trails are in progress for a range of fruit and vegetables on multi-use folding plastic crates. Introducing these has the potential to reduce life-cycle emissions by 4%. No information is available on testing this within the pineapple export sector.

4. **Transport within Europe - up to 5% possible**
   Reductions in emissions could be made through selecting transport companies that have low carbon systems in place, such as speed restrictions on their vehicles. A new generation of trucks is under development that has more efficient engines than conventional vehicles. In addition emissions reductions could be made through ensuring regular maintenance of vehicle and container refrigeration units. Though this may not always be within the control of the importer, as the shipping containers used are not their property and cold storage facilities in the ports may be out of their control.

Most of these improvements are ones that will improve efficiency and reduce costs in the value chain and so are worth pursuing even without market demand for low-carbon fruit. In

[4] Range of emission factors for N fertilizers (not including N_2O emissions from soil). AN = ammonium nitrate; FE = Footprint Expert: AN manufacture best available technology = 2.7 kg CO_2e per kg N; AN manufacture FE standard emission factor = 8.2 kg CO_2e per kg N; AN application (FE standard) = 4.8 kg CO_2e per kg N; AN application IPCC 2006 methodology (N_2O) = 6.2 kg CO_2e per kg N; Urea manufacture European average (2006) = 1.58 kg CO_2e per kg N; Urea manufacture best available technology = 1.13 kg CO_2e per kg N; Urea manufacture FE standard emission factor = 3.09 kg CO_2e per kg N. From Brentrup, F. and Paliere, C. (2008). GHG emissions and energy efficiency in European nitrogen fertilizer production and use. In: Proceedings of The International Fertilizer Society Conference, 11th December 2008. Cambridge, UK.

addition reducing use of fertilizer and fuel helps protect the industry from shocks due to fluctuations in the world price of oil.

5. OBJECTIVE FOUR: COMPARISONS OF DIFFERENT PINEAPPLE EXPORT PRODUCTS

This desk study compares emissions from whole sea-freighted pineapples (assessed in Objective One using PAS 2050) with alternative forms of processing or forms of transport. The comparison was carried out for the whole value chain; as far as possible this followed the protocols of PAS2050, though almost all data was secondary data. It was assumed that emissions from production of pineapples on the farm remained the same regardless of the method of processing or transport. It was assumed that processing would have occurred in an adjacent factory, close to the farm such that no significant additional transport emissions were incurred.

Different forms of fruit for export are compared, in each case using 100 grams of edible fruit flesh as the basic unit. For example, for dried pineapple the calculation starts with 100 grams of fruit-flesh which is then dried, packed and exported; for juice the amount of juice extracted from 100 grams of fruit-flesh is used as the unit.

To ensure the methodology remained simple, all farm production emissions were the same for all types of pineapple product. However, in a real life scenario producing for processing may lead changes in farm management and different farm emission profiles; a drying business may buy Smooth Cayenne which can be grown with less fertilizer, tops can be used for planting (eliminating the need for sucker production) and a drying factory may use the factory waste to generate biogas for powering the dryer and the digester sludge sent back to the farm to recycle plant nutrients.

Real pineapple processing facilities often produce a range of co-products (e.g. a factory for canned pineapple would most likely also produce pineapple juice). This reduces wastage and can thus lower the carbon footprint of each of the co-products. This aspect has been deliberately overlooked in this study, because of the shortage of data on this issue, but also to make the analysis clear and straightforward.

The objective of this study was to provide an approximate comparison of the likely carbon footprints of different types of pineapple product. Because of the data used, comparisons of small differences between alternative products should be made with great caution. While these results are approximations, we believe that they do give a reasonable basis for comparison, to show major differences between one product type and another, and to reveal potential emissions ‘hotspots’.

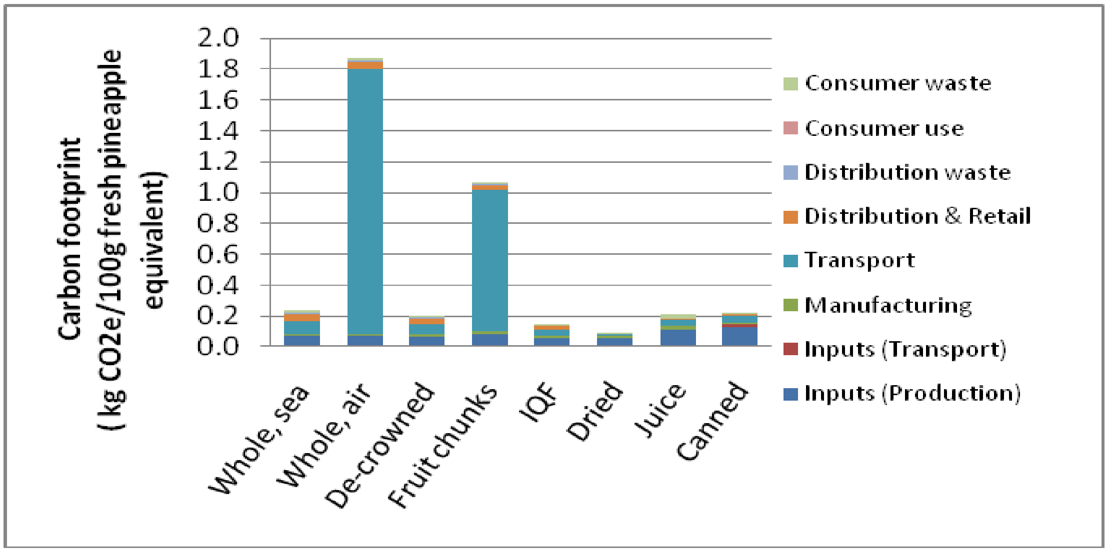


Fig 3: Comparison of the carbon footprint of different pineapple products including the two forms of air freight (wholefruit by air, and fruit-chunks by air).

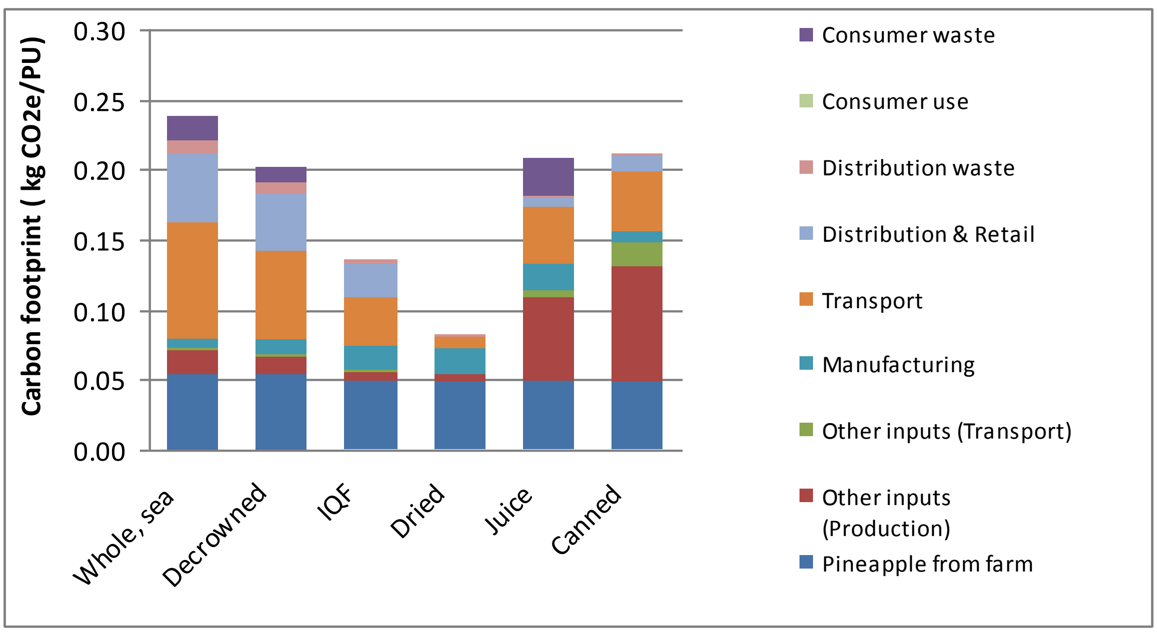


Fig 4: Comparison of the carbon footprint of different processing methods for pineapple, (excluding those using air freight).

The study was based on hypothetical product life-cycles (for example there is no export of tinned pineapple from Ghana). Assumptions were made as to the most likely production process for each individual product, information from individual pineapple processors, and information from technical data sheets for each piece of equipment likely to be used. Data derived in this way will always carry a degree of uncertainty, as resource consumption and other activity data may vary from factory to factory, depending on the actual processing equipment and processing parameters used.

Both forms of air-frieghtproduct (Fruit chunks by air and Whole fruit by air) have a carbon footprint far above the other six forms of pienapple export. For air-frieghted produce there seems to be little opportunity to reduce emissions substantially. For all other types of export there are believed to be opporuntities to substantially reduce emmissions.

6. CONCLUSIONS

Objective One: the assesment of the carbon footprint of fresh pineapple has been done by expert consultants and in a way consistent with PAS2050 methodology; this has been verified by an independent check. At this time this is the only case-study using PAS2050 on West African pineapple that is publically available The other three studies summarised here have each provides additional analysis and insight into the areas they cover.

<u>Main points emerging from these studies:</u>

- The quality of the PAS2050 calculation was verified and it was confirmed that the quality of the analysis was good and that a PAS2050 certificate could be issued with little additional effort.

- GHG emmissions is not the only environmental impact of pineapples produced in Ghana. Soil erosion is a issue for the industry in West Africa as it is in other producing regions of the world. Pesticide use/ecotocicity, eutrophiction and land-use change are other environmental impact areas that should be watched.

- Measuring the GHG emmission or GWP of fresh pineapple using PAS2050 was complex and would not have been possible without external consultants familiar with the methodology and the emmissions-factor databases that are required. The cost means that this type of study would be very expensive for many small and medium exporters.

- This emmissions profile and final calculated footprint is almost certainly broadly similar for all farms exporting whole MD2 by sea to Europe from West Africa. This study can therefore be used as a case-study and benchmark by other businesses.

- The study shows there are many ways of imroving efficiency and redcuing emmissions. More and more technology that can reduce emmissions is becoming available, some products mentioned looked at in these studies are very new to market and are essentially experimental.

- Most of the changes that reduce emmissions are effective because they eliminate waste. Eliminating waste reduces value chain costs. This means that managing businesses to reduce GHG emmissions is also likely to make them more profitable. When higher efficiency reduces dependence on inputs (mainly fuel and fertilizer) derived from oil and hydrocarbons then higher efficiency also helps protect businesses from input price shocks.

- Within the pineapple industry there is very little agronomic research in the public domain and almost none that is relevant to West African producers today. There is a case for businesses in different countries to collaborate through their business associations with internationalparteners to create public-private partnership programmes for research and trails the results of which can be shared across the industry.

- Being aware of issues related to GHG emmissions can prepare the pineapple industry for the middle and longer term future when there is expected to be increasing discrimination (through regulation and market prefeerences) against high GHG emmissions products.

- The comparison of different pineapple products (air, seafright, juice, dried, IQF ect) shows that even if some pineapple products face discrimination in future due to their high emmissions there is scope for the industry to adapt to production of low GHG emmissions forms of pineapple for export, as as scope to reduce emmissions substantially within each product type.