The Climate Impact of Plant-based Ready-to-Use Therapeutic Food

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Report prepared by:
Dr. Leigh Holloway,
Bernardo Salomon, Aoife Greene and Brian O'Kennedy

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Executive Summary

This report assesses and compares the climate impact (presented as global warming potential (GWP) measured in Carbon Dioxide Equivalent – CO_2e) of two RUTF nutritional products: A plant-based recipe (**SMS-RUTF**) and a peanut and milk-based recipe (**PM-RUTF**).

The assessment covers raw material production, supply chain transport, processing to RUTF, packaging, and transport up to the point of final distribution in the country of interest.

The climate impacts are shown in Table 1 (over). The total impact is per tonne of RUTF product packaged and delivered to the final customer location. It varies from 5.02 to 5.29 tonnes CO_2e for PM-RUTF and 2.43 to 2.79 tonnes CO_2e for SMS-RUTF. The variations within a particular product can be attributed to the various locations the product is manufactured in, largely as a result of the electricity grid mixes that each area primarily uses.

The study reveals that, the SMS-RUTF had a considerably lower total CO2e, being approximately 50% of the total CO2e of PM-RUTF. Whether manufactured in Africa, France or the USA, the overall impacts of the SMS-RUTF including raw materials, processing, transportation in the supply chain and for final delivery, and packaging are almost half those of the PM-RUTF.

It should be noted that in a Randomised Controlled Efficacy Trial undertaken in Malawi in 2016, it took an average of 3.2 additional days of treatment (equating to a prudent/worst-case scenario average of 8% more product) with SMS-RUTF to achieve recovery based on weight gain, and the child was then also found to be iron replete and non-anaemic upon discharge. The P-Milk recipe did not achieve this important result on iron status upon discharge three days earlier. Therefore, and even applying this additional amount of product to SMS-RUTF, the advantage over P-Milk on all key criteria remains significant.

The largest contributor to the overall life cycle CO_2e impacts of the SMS-RUTF and PM-RUTF types are the ingredients. For PM-RUTF the contribution of ingredients varies from 86-90% depending on the country of manufacture and for SMS-RUTF it varies from 74-85%. One ingredient to alter the CO_2e dramatically was the dried milk powder which is imported from a European country to Africa for PM-RUFT manufacturing. Another large category was found to be the packaging with the SMS-RUFT using 28% less packaging throughout its processes.

The biggest savings in climate impact per tonne of the SMS-RUTF compared to the PM-RUTF is in the raw ingredients (including processing). The former having a GWP per tonne for ingredients of 45% compared to the latter. Packaging impacts of the SMS-RUTF are 91% of those of the PM-RUTF and supply chain

transport impacts of the SMS-RUTF are between 26% and 84% of those for the PM-RUTF, depending on the country of manufacture.

Due to lack of data on the impacts of certain ingredients, the climate impacts of the micronutrients are estimated. These make up only 2.5% and 1.6% of the overall weight of the SMS-RUTF and PM-RUTF products respectively. Given the low percentage, these do not significantly impact the overall findings of the assessment.

It should be noted that no primary data was available for impact calculations and therefore the information used to assess climate impacts GWP (CO_2e) has been sourced from third party databases, machine specifications and published studies.

For studies to be used in comparative assertions and intended to be disclosed to the public, ISO 14044 asks for an analysis of results for sensitivity and uncertainty. Uncertainties of datasets and chosen parameters are often difficult to determine by mathematically sound statistical methods. Hence, for the calculation of probability distributions of Life Cycle Assessments (LCA) results, statistical methods are usually not applicable or of limited validity. To define the significance of differences of results, an estimated significance threshold of 10% is chosen as a pragmatic approach. This can be considered a common practice for LCA studies comparing different product systems [Kupfer et al. 2017]. This means differences ≤ 10 % are considered as insignificant and can therefore be unaccounted for.

Table 1 – Summary of GWP Impacts of SMS-RUTF and PM-RUTF

	Africa				America				France			
	PM-RUTF		SMS-RUTF		PM-RUTF		SMS-RUTF		PM-RUTF		SMS-RUTF	
	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne
Peanut Paste	230	0.67			230	0.67			230	0.67		
Skimmed Milk Powder	282	3.53			282	3.53			282	3.53		
Soy (extruded)			285	1.24			285	1.25			285	1.23
Maize (extruded)			55	0.04			55	0.04			55	0.04
Sorghum (extruded)			35	0.01			35	0.01			35	0.01
Defatted soy flour (extruded)			85	0.37			85	0.37			85	0.37
Vegetable Oil	172	0.10	235	0.13	172	0.10	235	0.13	172	0.10	235	0.13
Palm Stearin Oil	40	0.10	40	0.10	40	0.10	40	0.10	40	0.10	40	0.10
Sugar	250	0.14	225	0.13	250	0.14	225	0.13	250	0.14	225	0.13
Stabilizer	10	0.00			10	0.00			10	0.00		
Micronutrients	16	0.01	25	0.02	16	0.01	25	0.02	16	0.01	25	0.02
Amino Acids			15	0.03			15	0.03			15	0.03
Total	1000		1000		1000		1000		1000		1000	
Foil / sachet packaging (for RUTF)	21.7	0.14	21.7	0.14	21.7	0.14	21.7	0.14	21.7	0.14	21.7	0.14
Secondary Packaging (cartons) (for RUTF)	25.4	0.03	25.4	0.03	25.4	0.03	25.4	0.03	25.4	0.03	25.4	0.03
Secondary Packaging (PE Liners) (for RUTF)	7.2	0.02	7.2	0.02	7.2	0.02	7.2	0.02	7.2	0.02	7.2	0.02
Ingredient Packaging (as received at factory)	45	0.15	8	0.12	45	0.15	8	0.12	45	0.15	8	0.12
Factory manufacturing process		0.02		0.02		0.03		0.03		0.02		0.02
Ingredient delivery to factory		0.10		0.03		0.02		0.02		0.02		0.02
Delivery of product to final user		0.02		0.02		0.36		0.36		0.30		0.30
Total CO2e Impact (Tonnes)		**5.02**		**2.43**		**5.29**		**2.79**		**5.21**		**2.68**
			Difference	52%			Difference	47%			Difference	49%

NB: Total CO_2e impact figure excludes the contribution from micronutrients

Transport impacts to final market (Africa) are the same for SMS-RUTF and PM-RUTF but vary depending on country of manufacture. The contribution varies from 0.4% to 13% of total CO2e.

The transportation of raw ingredients for the PM-RUTF has considerable impacts when manufactured in Africa compared to the USA or France. All ingredients can be sourced locally in Africa except the dried skimmed milk powder and micronutrients which are usually sourced from Europe.

The largest impact of all the raw materials in the PM-RUTF is the milk powder, contributing between 67-70% of the total life cycle CO_2e depending on country of manufacture. The extruded grains used in the SMS-RUTF contribute a total of 60-68% to its total life cycle CO_2e.

Another scenario considered was the manufacture of the two alternative RUTF products in countries other than Africa (France and USA) and air-freighting the finished packaged products into Africa.

In this case, the calculated climate impact savings per tonne of finished RUTF product (of either type) transported by air, compared to manufacturing in Africa, was 4.8 tonnes CO_2e from France and eight tonnes CO_2e from the USA. The saving of CO_2e on product delivery to customer is over 99% when compared to distribution from a local location in Africa.

Context of the Study

VALID Nutrition ("VALID") is an independent and largely voluntary Irish and UK registered charity (www.validnutrition.org). Following a breakthrough R&D programme undertaken in three separate countries (Zambia, DRC, Malawi) over 15 years and supported by **Irish Aid**, the **Japanese Government (JICA)** and the **Global Innovation Fund**; VALID has developed a game-changing, amino-acid enhanced, plant-based, **Ready-to-Use Therapeutic Food (RUTF)**. The final stages of the research, involving the addition of crystalline amino acids to the base recipe, were undertaken with **Ajinomoto Co. Inc**.

RUTF is used to treat **Severe Acute Malnutrition (SAM)**. It is a lipid based, nutrient dense paste which is packed in 92g foil sachets from which the child can directly consume the product. For 20 years now there has been only one available milk-peanut based RUTF recipe. The product is acquired directly from producers by the UN (primarily UNICEF), governments or NGOs and then distributed to starving children through structured, community-based, healthcare programmes in countries where SAM occurs. The global market for RUTF has gone from around 1,000 Metric Tonnes (MT) per annum in 2007 to over 80,000 MT today. However, while this may seem like strong growth, the reality is that only **10-15% of children needing treatment with RUTF are being reached.** This figure is based on incidence rates not prevalence rates. The latter is more commonly used but is inappropriate in the context of SAM and flatters treatment statistics by reflecting the more commonly quoted 23-25% rate.

There is a limit to the amount of donor funding available each year to UNICEF and governments to finance treatment of SAM. Currently, RUTF accounts for 50% of each child's treatment cost on average – the other 50% being the programmatic costs associated with provision of the product to children at local level. Therefore, the purpose of VALID's 15-year product innovation was threefold:

- To achieve a **meaningful reduction in the cost of RUTF** overall without compromising on efficacy - meaning that within existing budgets, potentially hundreds of thousands more children can be treated per annum.

- To **reduce obstacles associated with local production** - not least cost of debt and the cost of importing inputs, as well as lead times on working capital. This burden can be relieved by efficacious, alternative recipes designed to locally available inputs and thus specifically conducive to local sourcing and manufacturing.

- To **mitigate against climate change** (and its disproportionately adverse effect on the populations of the developing world) **by improving the environmental impact profile of the product**. This involved using more locally available ingredients and obviating the requirement for African producers to import skimmed milk powder and (often) peanut paste.

Concurrently, this allows local manufacturers to be much more competitive – thereby increasing their market share at the expense of imports from Europe or the USA.

Goal of the Study

The goal of this study was to assess the climate impact of two alternative RUTF nutritional products.

VALID Nutrition commissioned this work to quantify objectively the overall climate impact profile of a new plant-based recipe for ready-to-use therapeutic food. This was compared to a peanut and milk-based recipe currently available on the market. The two alternatives are:

- SMS-RUTF (new, amino acid enhanced, plant-based recipe).
- PM-RUTF (current peanut and milk-based recipe).

The commissioner intends to use and reference this work in VALID Nutrition's advocacy efforts to governments, UN agencies and NGOs – and to act as evidence of the superior environmental profile of this recipe. This is a comparative assessment that is to be disclosed to the public.

Although this study is not a full life cycle assessment, the approach adopted does follow some of the requirements of ISO-14040 (ISO 2006). It is not fully compliant with the standard however, as only a single environmental impact is measured and presented.

Scope

The scope of this study covers the specific parts of the product system being considered.

Function and Functional Unit

The results of the study must relate to the functional unit. The functional unit refers to the function of the product, which in this case is to treat a malnourished child. As each sachet is 92g, they are packed into cartons of 150 sachets (13.8 kg). The conversion factor used for cartons to metric tonne (MT) is 72.46. Typically, treatment per child is equivalent to one carton, and "per MT" tends to be currency used for comparing recipes. The functional unit used therefore is a metric tonne (tonne, t or MT) of finished product used to treat malnourished children.

System Boundary

The model for both recipes followed a cradle to gate boundary with an extension modelling the distribution of finished product to Africa compared with from Europe or the USA. The cradle to gate analysis follows the production of ingredients (including all planting, though husbandry and harvest, to processing into ingredient form), transport of ingredients to processing site, processing of ingredients into final product and distribution of final product to the UNICEF warehouse in Lilongwe, Malawi. (Figure 1). All energy and materials flow within the cradle to gate scope were included within the assessment.

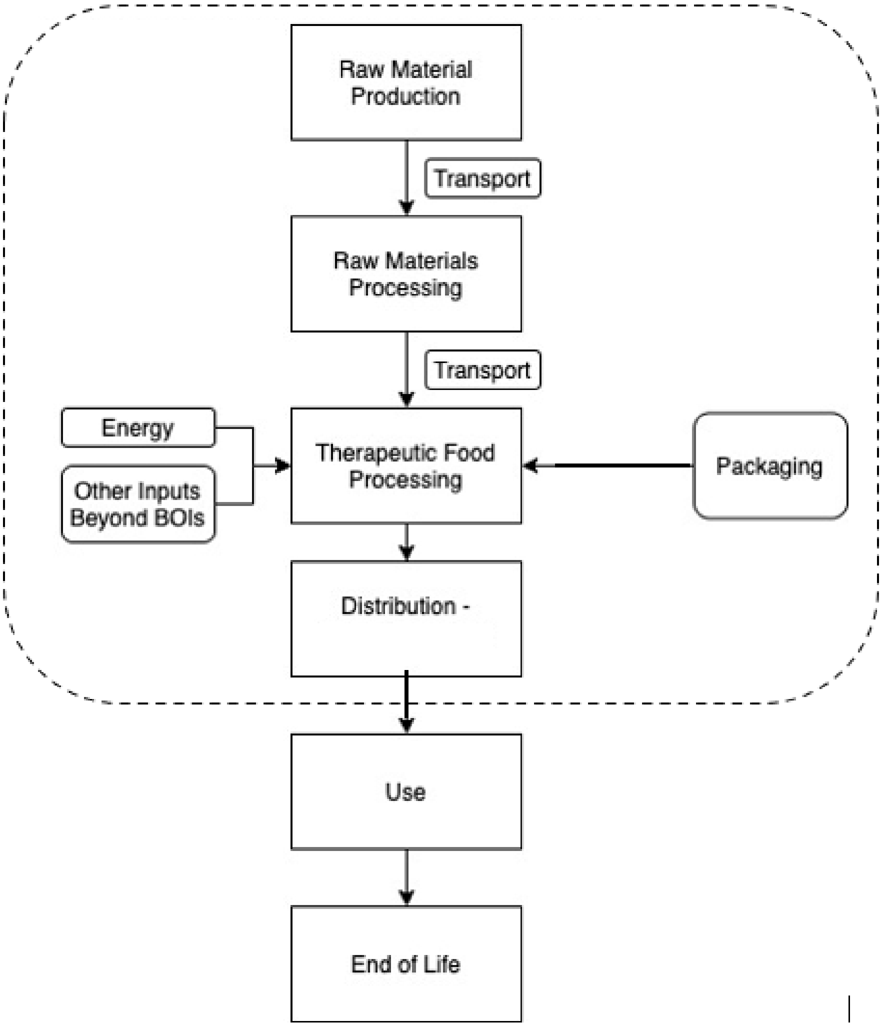


Figure 1 – System Diagram of the Study[1]

Each of the alternative RUTF products undergo different processing during the pre-processing of raw materials and then almost identical processing steps at mixing into RUTF and packaging.

Raw Materials (Ingredients)

The product system describes how both products, plant based, and peanut and milk-based recipes are delivered throughout their life cycle within a cradle to gate boundary. The ingredients for each are shown in Table 2.

[1] Everything within the dotted box is included in the study and everything outside is excluded

Table 2 – Ingredients used in RUTF Alternatives

SMS-RUTF Ingredients	PM-RUTF Ingredients
Soy (extruded)	Peanut Paste
Maize (extruded)	Dry Skim Milk
Sorghum (extruded)	Palm Oil
Defatted soy flour (extruded)	Palm Stearin
Vegetable Oil	Vegetable Oil
Palm Stearin	Sugar
Sugar	Stabilizer
Micronutrients	Micronutrients
Amino Acids	

The impacts of these ingredients include the processing routes that they undergo before delivery to the factory for final conversion into the SMS-RUFT or PM-RUTF.

As per Table 3, some of the ingredients are packaged in specific packaging to be sent on to final manufacturing.

Table 3 – Packaging Used in RUTF Alternatives

SMS-RUTF Ingredients (extruded grains mixed with defatted soy flour)		PM-RUTF Ingredients (Peanut paste)	
Unit weight = 25kg		**Unit weight = 20kg**	
Packaging	**Weight**	**Packaging**	**Weight**
Gunny Sack (HDPE woven)	100g	HDPE Bucket	800g
HDPE Liner	100g	HDPE Liner	100g

Sourcing of Ingredients

For both recipes, VALID Nutrition sourced the remaining bill of ingredients through a range of suppliers. These were then sent to the final location for production.

RUTF Packaging

After final processing the RUTF is packaged into sachets. Each full sachet is 94g; 92g of RUTF and 2g of foil packaging. They are packed into cartons with 150 sachets per carton. These cartons use a plastic liner. A full breakdown of packaging weight is shown in Table 4.

Table 4 – Final Packaging for RUTF Products

Packaging component	Weight (g)	Number per carton
Foil sachet	2	150
Carton Liner (LDPE)	100	1
Carton (Corrugated Board)	350	1

See the 'System Boundary' section of this report and Appendix 1 for flowcharts showing the raw materials and processing steps used for each of the RUTF alternatives.

Transportation

The product system includes the transportation of raw materials and pre-processed products (extruded grains and peanut paste). Depending on where the product is manufactured, the transport routes and mode of transport used vary. Table 5 shows a summary of the locations and transport route options considered in this assessment.

The assessment considered a range of combinations of locations for the sourcing of materials as well as the pre- and final processing. The option of purchasing the finished packaged RUTF product from a specific location and shipping directly to the country of end use was also considered.

In cases where the PM-RUFT product is manufactured in Africa, all the ingredients can be sourced locally, except skimmed milk and micronutrients which are imported. For SMS-RUTF product, only amino acids and micronutrients are imported.

It is also important to note that on some occasions due to shortages of quality peanuts within Malawi, peanut paste is sourced from other locations such as South Africa and Latin America; however, this has not been modelled within this system.

See Appendix 3 for details of the specific distances and modes of transport used in the calculations.

Table 5 – Locations and Transport Options for Different Manufacturing Locations.

	Country of manufacture SMS/PM RUTF ingredients		
	Africa – Lilongwe	**France – Normandy**	**USA – Pendergrass, Georgia**
Soy (Extruded)	Sourced locally – Road	Sourced locally – Road	Sourced locally – Road
Maize (Extruded)			
Sorghum (Extruded)			
Defatted Soy Flour			
Vegetable Oil			
Palm Stearin			
Sugar			
Stabilizers and Amino Acids	Sourced from Germany – Sea	Sourced from Germany – Road	Sourced locally – Road
PM – Peanut Paste	Sourced locally – Road	Sourced locally – Road	Sourced locally – Road
Dried Skimmed Milk Powder	Sourced from Ireland – Sea	Sourced locally – Road	Sourced locally – Road
Micronutrient Pre-Mix Source	Sourced from Germany – Sea	Sourced from Germany – Road	Sourced locally – Road
Port of Entry to Africa for ingredients not locally sourced	Beira, Mozambique for sea / or Lilongwe if by Air*	Beira, Mozambique for sea / or Lilongwe if by Air*	Beira, Mozambique for sea / or Lilongwe if by Air*
Distribution location of Final Product Sales	Malawi	Malawi	Malawi

* Air transport only used in specific circumstances and this assessment is done using sea transport as the default unless otherwise stated.

SMS-RUTF Ingredient Processing

An extruded blend of grains for SMS-RUTF is processed in the following steps:

- Soya beans, maize, and sorghum are cleaned (5% wastage).
- Weighing and mixing the clean grains and defatted soy at the correct ratios.
- Extruding the blend (3% wastage).
- Milling with a hammer mill.

The typical yield of the milled flour blend is 92% - i.e., a loss of 8% occurs mainly from raw grain cleaning (dirt) and process (moisture).

PM-RUTF Ingredient Processing

Peanut paste for PM-RUTF is processed in the following steps:

- Cleaning grading and sorting of shelled peanuts.
- Roasting.
- Blanching.
- Milling to a smooth paste of <200 microns particle size. This can result in a wastage of 23.5%. No salt, supplements nor other additives are added. When PM-RUTF was produced at Valid Nutrition in Lilongwe, Malawi the peanut process either occurred on site in the factory or this demand was supplemented by a pre-processed peanut paste from Malawi.

Final RUTF Manufacture

Both the SMS-RUTF and the PM-RUTF undergo the same final processing steps. This process involves mixing of the pre-processed ingredients with a range of other ingredients including a micronutrient pre-mix.

Micronutrient Pre-Mix

The micronutrient premix for both the SMS-RUTF and PM-RUTF is sourced from Germany.

The full bill of ingredients for the two RUTF alternatives is detailed in the 'Life Cycle Inventory' section of this report.

Final RUTF Packaging

The packaging used for both recipes is identical due to regulatory requirements for therapeutic food products. Therefore, comparatively, a zero-burden assumption can be accepted, in that the impact of packaging will be zero to insignificant, not affecting the comparison between the two recipes.

However, the weight of the packaging is used in some of the studied scenarios. Most importantly, the shipping of final and fully packaged product.

Distribution and Manufacturing Location

Several different scenarios have been considered in this assessment relating to the location of the manufacturing of the two RUTF recipes. The SMS-RUTF was produced in Malawi by Valid Nutrition. However, both RUTF products can be produced overseas in France or the USA and either transported by sea or air freight to Africa. Various scenarios have been assessed to determine the impact of this distribution stage with respect to both products and how they compare. The scenarios that were considered are as follows:

- PM versus SMS – both products made in Africa.
- PM versus SMS – both products made in USA.
- PM versus SMS – both products made in France.
- PM versus SMS – the former made in France and the latter produced in Africa.

Finally, the transport impacts of air freighting PM-RUTF or SMS-RUTF into Africa from both the USA and France were also assessed.

Methodology and Impacts Considered

A carbon footprint of environmental life cycle impact assessment is the categorisation and quantification of the environmental impacts of the studied system based on the collected data in the inventory.

This study adopts a life-cycle approach but only considers one impact categorisation – climate impacts measured as GWP and presented as CO_2e.

Allocation Procedure

Allocation refers to partitioning of input or output flows of a process or a product system between the product system under study and one or more other product systems [ISO 14044, definition 3.17]. Different processes within a product system can sometimes produce multiple by-products in addition to the production of the functional unit.

Th ISO definition comprises the partitioning of flows regarding by-products, re-use and recycling, particularly open loop recycling. In this study there is no reuse or recycling within the system, therefore these are not a consideration in allocation. However, by-product allocation has been considered in the study. The calculation model uses pre-allocated datasets that have already considered the appropriate upstream allocation of by-products within the LCIA calculation. Therefore, when the data is used in this calculation the results presented include the impacts / benefits of any by-products resulting from the system that are not directly related to the functional unit.

Data and Data Quality Requirements:

Data

The main data sources for this study are primary data and secondary data. The primary data was gathered by the VALID Nutrition team in relation to the bill of ingredients, product weight, manufacturing energy use, modes of transport and distances, and port of distribution. The main secondary data was sourced from industry standard databases such as EcoInvent v3.8 and published literature which was used to supply background information for ingredient production, energy related emission factors, transport emission factors, and key processing steps where possible. In the absence of any data in these databases, the specifications of relevant machinery were studied, and energy requirements or related impacts were estimated.

See Appendix 2 for a list of the datasets used and their sources.

Data Quality Assessment

Inventory data quality is judged by its precision (measured, calculated, or estimated), completeness, consistency and representativeness (geographical, temporal, and technological). To cover these requirements and to ensure reliable results, first-hand industry data (where available) in combination with consistent background LCA information from the EcoInvent v3.8 database were used. Overall, the foreground and background data used in this analysis are considered appropriate given study goal and scope.

Precision and Representativeness

- Precision: As the majority of the relevant foreground data for the manufacturing of RUTF products is data provided by VALID Nutrition or calculated based on primary information from relevant studies, precision is considered to be high. All background data is sourced from EcoInvent databases with the documented precision.
- Temporal: All primary data was collected for the period of years 2019/2020. All secondary data come from the EcoInvent v3.8 databases and is representative of the years 2010-2019. As the study intended to compare the product systems for the reference year 2019, temporal representativeness is considered to be high.
- Geographical: The data used in the analysis provide the best possible representation available with current data. Representative data used in the assessment are representative of "Rest-of-World" region in EcoInvent (average for all countries in the world with uncertainty adjusted). Datasets chosen are considered sufficiently similar to actual geographical coverage of processes.

- Technological: For the most part, data is representative of the actual technologies used for processing, transportation, and manufacturing operations. Where technology-specific data was unavailable, proxy data was used. Technological representativeness is considered to be high.

Model Completeness and Consistency

- Completeness: Except where noted, the LCA model included all known mass and energy flows. In some instances, surrogate data used to represent upstream operations may be missing some data which is propagated in the model. No known processes or activities were excluded; in total, these missing data represent less than 5% of the cumulative omitted mass or energy flows.
- Consistency: All assumptions, methods and data are consistent with each other and with the study's goal and scope. Data sources of similar quality and age are used, which are taken from EcoInvent v3.8. The consistency of the assessment is considered to be high.

Data Scope

Geographical scope: The data focus was on European and rest of world production as the products and ingredients are either sourced from Europe or Africa. Where European or African datasets could not be sourced, then global datasets were used.

Temporal scope: The primary datasets and assumptions used for the study has a target year where possible of 2019/20. If this was not available, data was collected for the next available year. Secondary sources of data such as database logs and literature have a reference period of 10 years but where possible will be in reference to the study year of 2019/20.

Technical scope: The specific data received from VALID Nutrition is in reference to the current practises to produce the SMS-RUTF and PM-RUTF. The generic industry data used in this study reflect process configurations, operations, and performance at the time of data collection. Where possible the most up to date technical performance data was used.

The data collected fulfilled the requirements of the time-related, geographical, and technological needs to represent the system of study appropriately. These guidelines were applied to all components and phases of the system to ensure consistency.

Assumptions

There is wastage found within the processing of raw materials inside VALID Nutrition's site for both RUTF products. In cases where the total wastage of a certain step of the processing stage was relating to more than one ingredient it was assumed that the wastage percentage was evenly split among all the ingredients.

For SMS-RUTF, grains (soybean, maize, and sorghum) are first cleaned, graded, and sorted which results in a combined 5% w/w wastage. Next, during the extrusion and milling stage, aforementioned grains and defatted soy flour have a combined material loss of 3%. Finally, according to VALID Nutrition the packaging of the final product results in an overall loss of 2.5% which is split evenly across all items from the bill of materials.

For PM-RUTF, the cleaning, grading, and sorting of the shelled peanuts equals an approximate material loss of 8.5%. Next, the roasting, blanching, and pasting of peanuts represents a wastage of 15%. Finally, the overall losses within VALID Nutrition's factory for the packaging of the final product result in about 2% which is split evenly across all items from the bill of materials.

For processing activities, the energy used in machinery is assumed to be all electrical and the amount used has been estimated from studying machinery specifications as no primary data was available. The foreground processing of both products is assumed to be the same.

Consistency & Uncertainty

While the study methodology is applied consistently to the materials and processes of the assessment, it should be noted that the majority of inventory data regarding ingredients and some of the conversion processes is based on generic data. Only the impacts of processing steps controlled by VALID Nutrition use specific data that has been required to be adopted. A combination of both data types, e.g., through integration of specific data into generic data sets, can lead to inconsistencies in mass and energy balances and thus the results. The effects of these inconsistencies on the results were checked and were not considered to be significant.

Due to the nature of LCA some limitations and uncertainties can occur, which can affect the overall results of the study. Most data was sourced from EcoInvent where possible. EcoInvent is an independent, third-party peer-reviewed dataset used widely in environmental studies, carbon foot printing exercises and life cycle assessment. Using data from such datasets is an accepted approach where primary data is not available.

Where impact data was not available in EcoInvent it was sourced from other datasets, and where no datasets contained the required impact, it was then located in various sources including peer-reviewed published papers and data sources such as machinery specification sheets.

Data on the impacts of the micronutrient pre-mix was not available in any of the datasets and could not be found. Therefore, it has been omitted from this assessment. However, as the absolute difference (0.9%) in the weight of micronutrient pre-mix for the respective RUTF recipes is small, the omission of these impacts will not affect the comparative assertions made in this study.

Assessments of this nature are open to uncertainty, derived from subjective choices and/or missing data. In this study the materials/ingredients used are clearly identified and quantified. The tool used to carry out the calculations clearly lists all data, sources assumptions and omissions. The data used is generic or specific that, while indicative of the process, may not fully reflect the impact of the specific processes actually in use.

Limitations

The results of the base scenarios and analysed RUTF systems and the respective comparisons between the two alternative RUTF systems are valid within the framework conditions described in earlier sections of this report.

The following limitations must be considered, however.

Limitations arising from the specification of RUTF. The results are valid only for the specific RUTFs with ingredients in amounts and proportions, the packaging specification and production locations as listed. The results cannot be considered to be representative of any other types of similar RUTF.

Limitations concerning the chosen environmental impact potentials and applied assessment methods: The environmental category 'Climate Impact' applied in this study covers assessment methods considered by the authors to be the most appropriate to assess the potential environmental impact. It should be noted that the use of different impact assessment methods for 'Climate Impact' could lead to other results concerning the environmental ranking of the two alternative RUTFs considered. The results are valid only for the specific characterisation model used for the step from inventory data to impact assessment.

Limitations concerning the analysed impact categories: The results are valid only for the environmental impact category 'Climate Impact', which is examined.

Limitations concerning geographic boundaries: The results are valid only for the indicated geographic scope and cannot be assumed to be valid in other geographic regions.

Limitations concerning the reference period: The results are valid only for the indicated time scope and cannot be assumed to be valid for (the same) RUTFs at a different point in time.

Limitations concerning data: The results are valid only for the data used and described in this report. To the knowledge of the authors, the data used represents the best available and most appropriate data for the purpose of this study. It is based on figures provided by the commissioner and data sources as referenced. For each RUTF alternatives the same methodological choices were applied concerning allocation rules, system boundaries and calculation of environmental categories.

Critical Review

This study has been subjected to an independent critical review. Therefore, in accordance with the ISO rules, claims to third parties regarding the outcome of this study are permitted.

The critical review was undertaken by Professor Nicholas M. Holden, University College Dublin.

The review comments are within Appendix 5 of this report. These comments have been addressed in this final version of this report.

Format of study

This study and report are not fully compliant with the ISO 14044:2006 standard but the approach used does follow the majority of guidelines and principles outlined in the ISO 14044:2006 standard. It also closely follows the requirements of the PAS-2050 standard, a method for quantifying product carbon footprints.

Life Cycle Inventory

Data for both RUTF systems was provided by VALID Nutrition in relation to product ingredients, processing steps, wastage within the processing site, location of production facility and shipping ports used which allowed the transportation distances to be determined. This information was supplemented with the industry accepted database of EcoInvent and published literature.

RUTF Ingredient Breakdown

SMS-RUTF bill of ingredients relating to the finished products weight per metric tonne and kg of ingredients including any wastage as a result of the processing steps.

Table 6 – SMS-RUTF Bill of Ingredients

Bill of Ingredients	Kg/Tonne	Kg/Tonne Including Processing Waste	Primary CO_2e Data Source
Soya Beans	286	294	EcoInvent V3.8
Maize	55	57	EcoInvent V3.8
Sorghum	35	36	EcoInvent V3.8
Defatted Soy Flour	85	86	EcoInvent V3.8
Palm Oil	235	236	EcoInvent V3.8
Palm Stearin	40	40	EcoInvent V3.8
Sugar	225	226	EcoInvent V3.8
Micronutrient Premix	25	25	Limited data from EcoInvent V3.8

PM-RUTF bill of ingredients relating to the finished products weight per metric tonne and amount of ingredients including any wastage as a result of the processing steps.

Table 7 – PM-RUTF Bill of Ingredients

Bill of Ingredients	Kg/Tonne	Kg/Tonne Including Processing Waste	Primary CO_2e Data Source
Peanut Paste	230	288	EcoInvent V3.8
Dry Skim Milk	282	283	EcoInvent V3.8
Palm Oil	122	122	EcoInvent V3.8
Palm Stearin	40	40	EcoInvent V3.8
Vegetable Oil	50	50	EcoInvent V3.8
Sugar	250	251	EcoInvent V3.8
Stabilizer	10	10	No Data
Micronutrient Premix	16	16	Limited data from EcoInvent V3.8

Processing

The SMS-RUTF processing stages are split into pre-processing activities and final processing.

Table 8 – SMS-RUTF Pre-Processing Steps

Pre-Processing Steps	Inputs	Data Comment	Data Source
Grain Cleaning	Energy	No primary data	Machine manufacturer specifications Grid electricity figures from ourworlddata.org
Mixing and Coarse Grinding	Energy	No primary data	
Extrusion	Energy, water	No primary data	
Milling (Hammer Mill)	Energy	No primary data	

The PM-RUTF processing stages are split into pre-processing activities and final processing.

Table 9 – PM-RUTF Pre-Processing Steps

Pre-Processing Steps	Inputs	Data Comments	Data Sources
Shelling Peanuts	Energy	No primary data	Life Cycle Assessment study of the impacts of manufacturing Peanut Butter in the USA (2014)
Cleaning, Grading, Sorting	Energy	No primary data	
Roasting	Energy	No primary data	
Blanching	Energy	No primary data	
Pasting	Energy	No primary data	

Both the SMS-RUTF and the PM-RUTF use the same final processing steps, detailed in Table 10.

Table 10 – Final processing steps for both SMS-RUTF and PM-RUTF

Final Processing Steps	Inputs	Data Comments	Data sources
Fine Milling of some Ingredients	Energy	Primary energy and water inputs for valid factory	Data supplied by Valid. Grid electricity figures from ourworlddata.org
Weighing	Energy		
Mixing & Blending	Energy		
Packaging and labelling			

Transport Stages

There are several transport stages considered for the manufacture of the RUTF products. The modes of transport used, and the distances covered differ across the various products and manufacturing locations. These are highlighted in Table 11.

Table 11 – Transport Stages for Both SMS-RUTF and PM-RUTF

Transport Steps	Inputs	Data Comments	Data Sources
Delivery of Raw Ingredients to Original Processor (Grains, Peanuts)	Fuel	Impacts calculated using tonne.km model Where items were sourced 'locally' a distance of 150km was assumed	CO_2e data from GLEC Framework 2021. Distances: Road – Google Maps Sea – Seadistances.org Air – Dstance.to
Delivery of Pre-Processed Product (Extruded Grains or Peanut Paste) to RUTF Factory			
Delivery of Other Ingredients to RUTF Factory			
Delivery of packaged RUTF to Customer (location Lilongwe, Malawi			

Packaging

Packaging is used at two stages in the process. For the transportation of pre-processed ingredients to the RUTF factory and for the final distribution of the finished RUTF products to the customers/users.

Table 12 – Packaging Used for SMS-RUTF and PM-RUTF

Packaging Stage	Inputs	Data Comments	Data Sources
PM-RUTF: Peanut Paste Packaging	Plastic buckets with liners	Injection moulded HDPE buckets with liners	EcoInvent V3.8
SMS-RUTF: Extruded Grains and Defatted Soy Flour Mix Packaging	Gunny sacks with liner	Woven HDPE bags with HDPE film liner	EcoInvent V3.8 and Third-party study
RUTF Packaging into Sachets for Both SMS-RUTF and PM-RUTF	Packaging materials	Metalized foil laminate film, plastic liners, and carton boxes	EcoInvent V3.8 and third-party studies

Results

PM-RUTF

The total GWP impacts for the PM-RUFT and the SMS-RUTF differ considerably, with the SMS-RUTF having a total GWP impact 48-52% lower than the PM-RUTF depending on the country of manufacture.

The difference in the overall GWP impact of the SMS-RUTF is similar across all three countries of manufacture, varying from 2.39 to 2.43 tonnes of CO2e per tonne of RUTF. This is also the case with the PM-RUTF which has an GWP impact of between 4.92 and 4.93 tonnes of CO2e per tonne of RUTF.

Table 13 – Total GWP (Impact per tonne of SMS-RUTF and PM-RUTF)

	Africa		**USA**		**France**	
	PM-RUTF	SMS-RUTF	PM-RUTF	SMS-RUTF	PM-RUTF	SMS-RUTF
CO2e (t)	4.92	2.41	4.93	2.43	4.92	2.39

Figures 2 and Table 14 shows the contributions of each stage of the life cycle to the overall impact. As can be seen the ingredients contribute most of the impact of both types of RUTF.

Ingredients (inclusive of any processing needed) contribute 92% of the total impact of the PM-RUTF and 85-86% to the total impacts of the SMS-RUTF.

Packaging contributes 7% to the total impact of PM-RUTF and 12-13% of the SMS-RUTF.

The processing impacts contribute only a small percentage but are different across various countries. The lowest is manufacture in France as the grid electricity CO_2e per kilo watt hour is lower in that country. However, the overall effect this has is minimal.

Transport across the supply chain (covering transportation of ingredients to pre-processing and final manufacturing locations) contributes a minimal amount to the overall impacts of <1%.

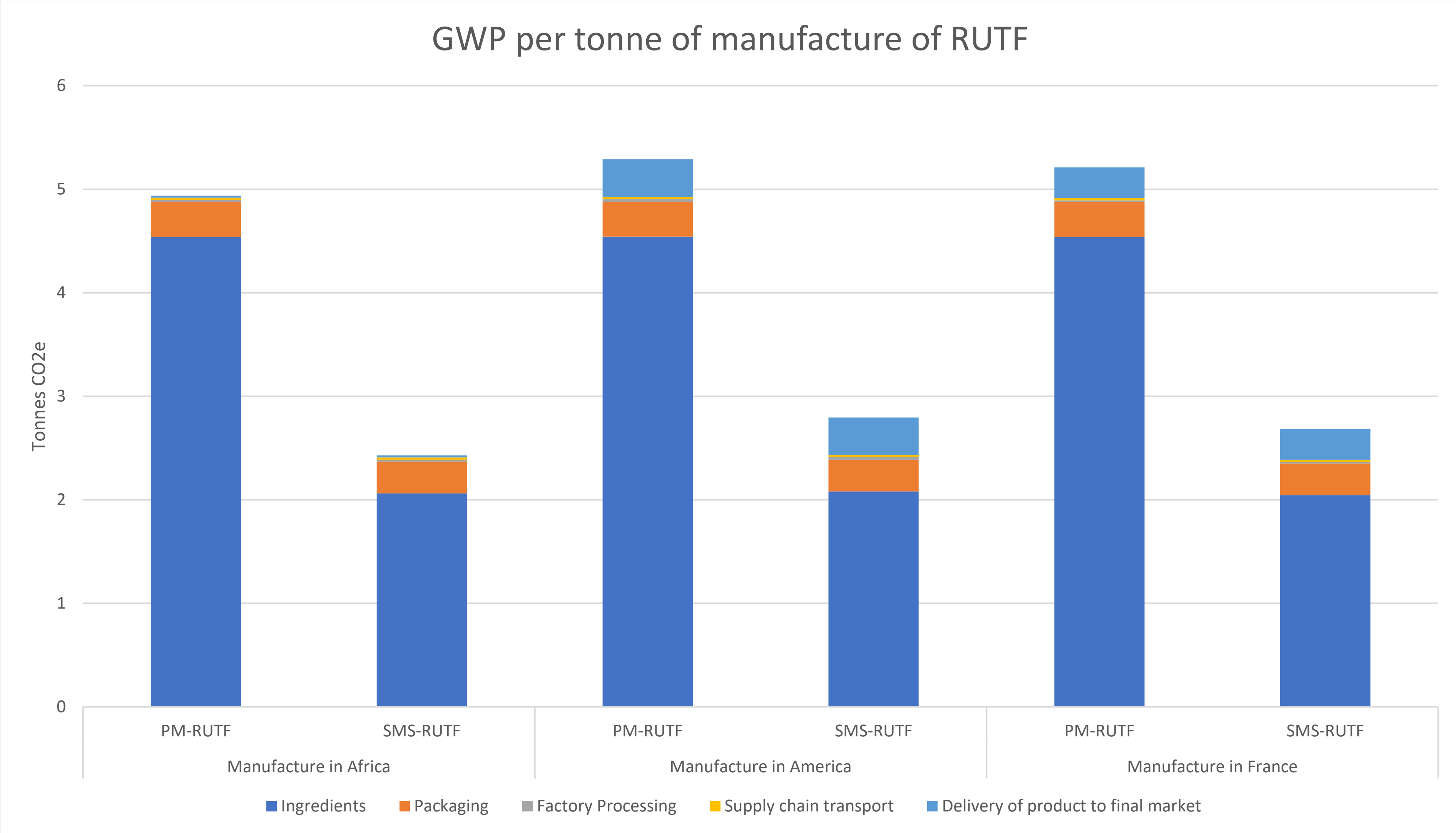


Figure 2 – Total Climate Impact in CO_2e per tonne of Different RUTF Product and Manufacturing Locations

Table 14 – GWP Impacts of SMS-RUTF and PM-RUTF

	Africa				America				France			
	PM-RUTF		SMS-RUTF		PM-RUTF		SMS-RUTF		PM-RUTF		SMS-RUTF	
	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne	Kg /tonne	CO2e/tonne
Peanut Paste	230	0.667			230	0.667			230	0.667		
Skimmed Milk Powder	282	3.52658202			282	3.52658202			282	3.52582062		
Soy (extruded)			285	1.239959			285	1.250648875			285	1.229269125
Maize (extruded)			55	0.039184933			55	0.041247892			55	0.037121975
Sorghum (extruded)			35	0.013293817			35	0.014606608			35	0.011981025
Defatted soy flour (extruded)			85	0.369812333			85	0.373000542			85	0.366624125
Vegetable Oil	172	0.09705788	235	0.13260815	172	0.09705788	235	0.13260815	172	0.09705788	235	0.13260815
Palm Stearin Oil	40	0.097668	40	0.097668	40	0.097668	40	0.097668	40	0.097668	40	0.097668
Sugar	250	0.1410725	225	0.12696525	250	0.1410725	225	0.12696525	250	0.1410725	225	0.12696525
Stabilizer	10	0			10	0			10	0		
Micronutrients	16	0.011399253	25	0.017811333	16	0.011999387	25	0.018749042	16	0.01079912	25	0.016873625
Amino Acids			15	0.025707			15	0.025707			15	0.025707
Total	1000		1000		1000		1000		1000		1000	
Foil / sachet packaging (for RUTF)	21.7	0.135842	21.7	0.135842	21.7	0.135842	21.7	0.135842	21.7	0.135842	21.7	0.135842
Secondary Packaging (cartons) (for RUTF)	25.4	0.0262636	25.4	0.0262636	25.4	0.0262636	25.4	0.0262636	25.4	0.0262636	25.4	0.0262636
Secondary Packaging (PE Liners) (for RUTF)	7.2	0.02304	7.2	0.02304	7.2	0.02304	7.2	0.02304	7.2	0.02304	7.2	0.02304
Ingredient Packaging (as received at factory)	45	0.15122	8	0.119568	45	0.15122	8	0.119568	45	0.15122	8	0.119568
Factory manufacturing process		0.020908		0.020908		0.026135		0.026135		0.015681		0.015681
Ingredient delivery to factory		0.104742422		0.027013636		0.024155519		0.020211697		0.023147199		0.020933897
Delivery of product to final user		0.019266658		0.019266658		0.362087526		0.362087526		0.295757866		0.295757866
Total CO2e Impact (Tonnes)		**5.02**		**2.43**		**5.29**		**2.79**		**5.21**		**2.68**
			Difference	52%			Difference	47%			Difference	49%

NB: Total CO_2e impact figure excludes the contribution from micronutrients

Comparisons

The overall total climate impacts per tonne of complete packaged and distributed SMS-RUTF and PM-RUTF show considerable difference across all countries of manufacture. The SMS-RUTF has a total GWP Impact (CO_2e) of 49-53% of that of the PM-RUTF depending on the country of manufacture.

Figure 3 shows the totals and the breakdown of the contributions of the total CO_2e per tonne of each alternative scenario in terms of type of RUTF and location of manufacture.

Figure 3 – Total CO2e Breakdown for RUTFs Manufactured in Different Countries

PM-RUTF versus SMS-RUTF – both products made in Africa

Figure 4 shows the difference in impacts of the two RUTF alternatives made in Africa and the breakdown of these.

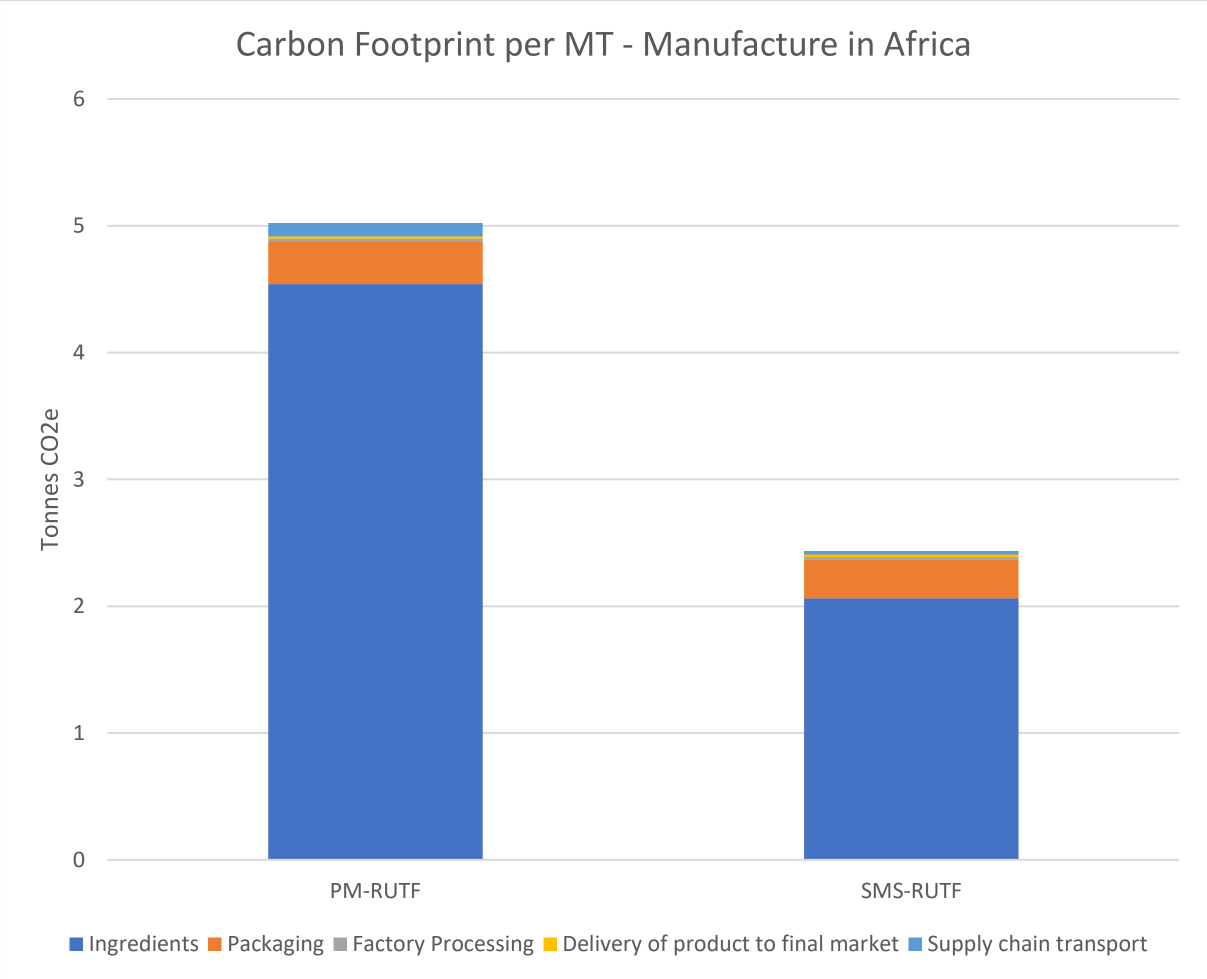


Figure 4 – Climate Impacts of PM-RUTF versus SMS RUTF, Both Products Made in Africa

As can be seen the SMS-RUTF raw ingredients have a much lower impact than those used in the PM-RUTF alternative.

The delivery of ingredients is also much lower as they can be sourced locally rather than having to bring dried milk powder from Europe (Ireland in this case) for the manufacture of the PM-RUTF.

There are also lower impacts for the SMS-RUTF in terms of the packaging used in the pre-processed ingredient delivered to Valid Nutrition in Malawi and the related delivery impacts due to a lower weight of packaging used per tonne.

PM versus SMS RUTF – both products made in USA

Figure 5 shows the difference in impacts of the two RUTF alternatives made in the USA and the breakdown of these.

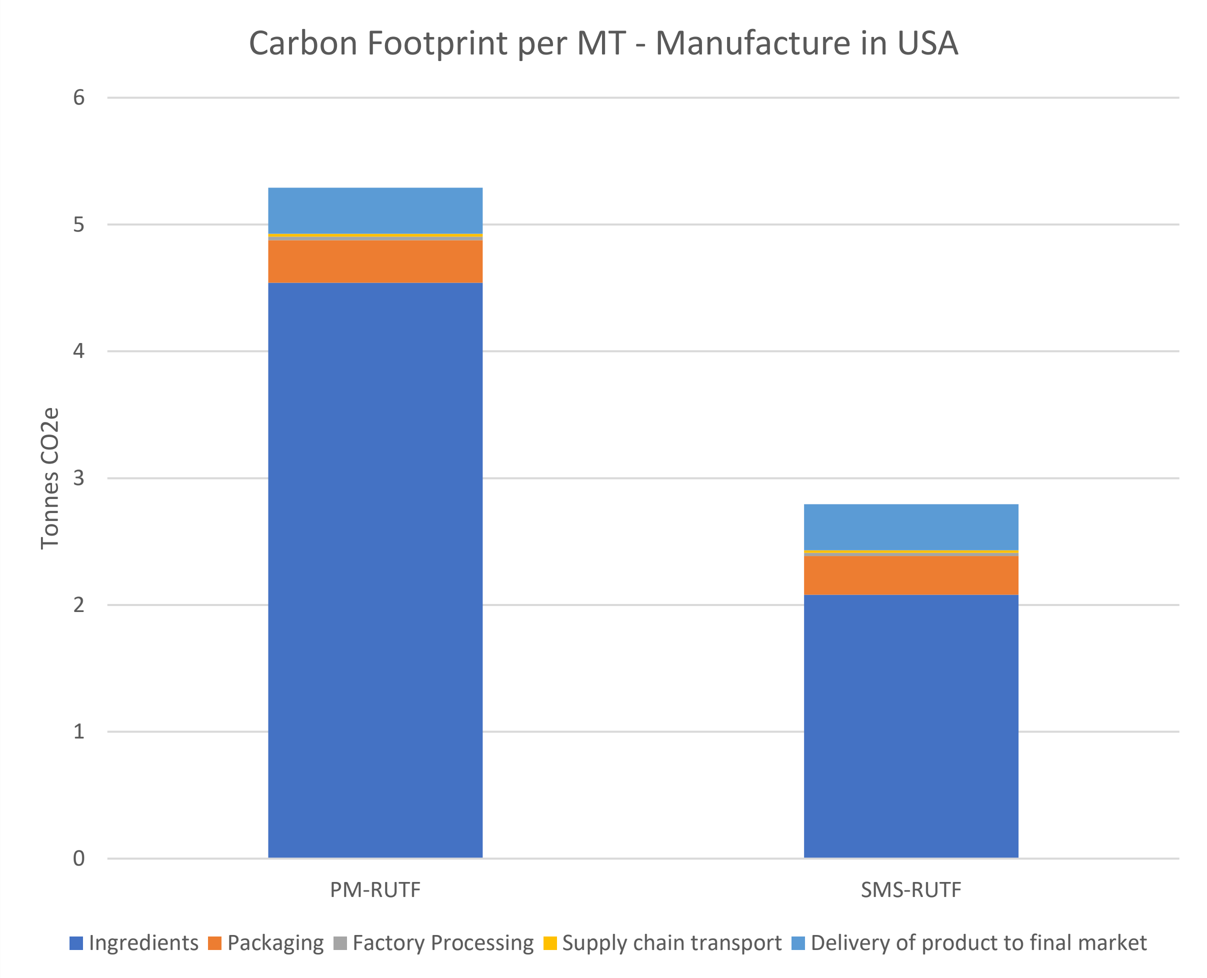


Figure 5 – Climate Impacts of PM-RUTF versus SMS RUTF, Both Products Made in USA

The overall pattern is again similar to the scenarios for manufacturing in Africa.

Manufacturing impacts are slightly higher than in Africa. This is in part due to the difference in grid electricity CO_2e, but the relative difference between SMS-RUTF and PM-RUTF are the same.

Again, the SMS-RUTF has a lower CO_2e impact per tonne in terms of ingredients, delivery of the goods, and packaging for the same reasons outlined in the previous scenario.

PM versus SMS RUTF – both products made in France

Figure 6 shows the difference in impacts of the two RUTF alternatives made in France and the breakdown of these.

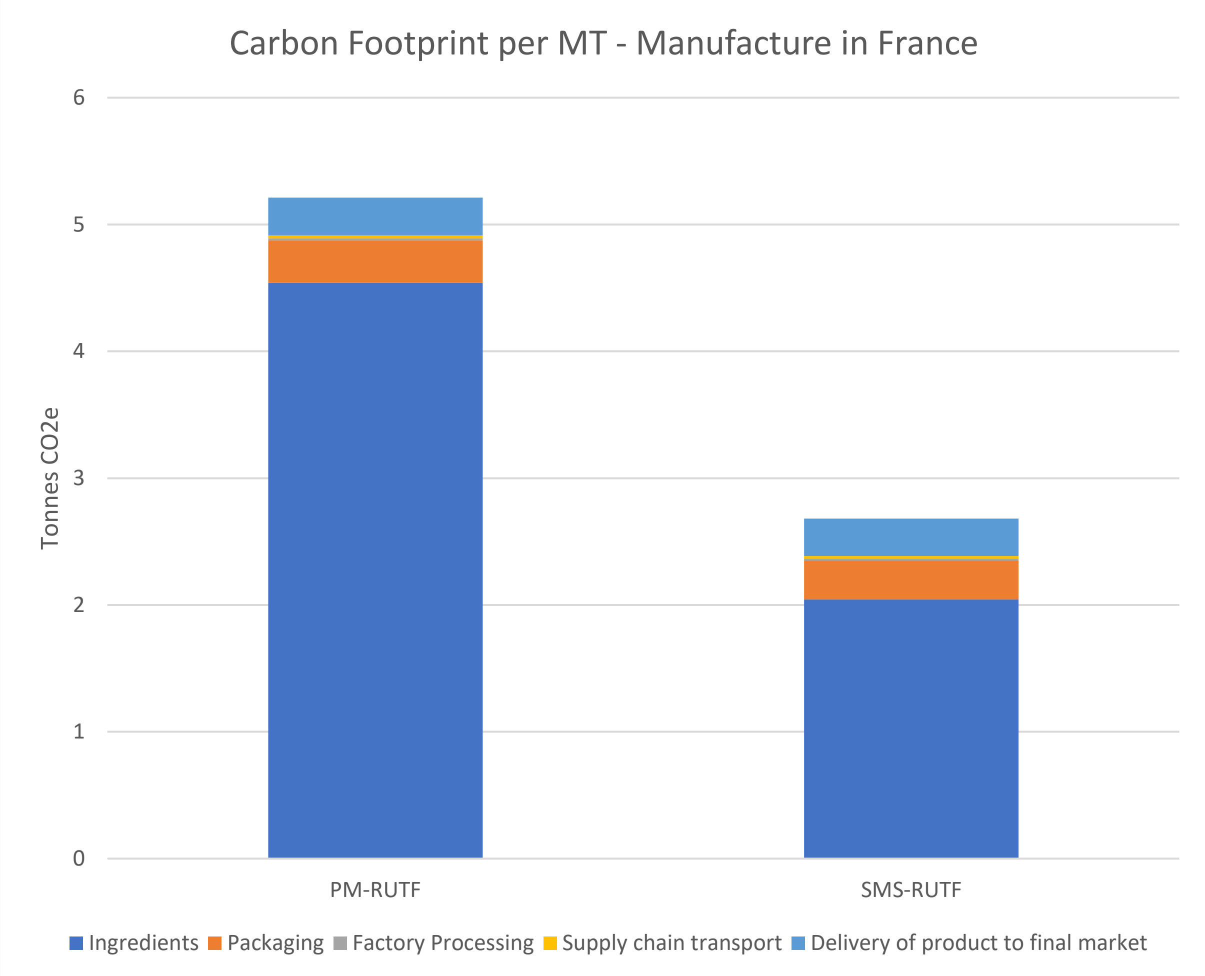


Figure 6 – Climate Impacts of PM-RUTF versus SMS RUTF, Both Products Made in France

Once again, the overall pattern is similar to the scenarios for manufacturing in both Africa and the USA.

Manufacturing impacts are slightly lower than in the USA due to the difference in grid electricity CO_2e, but the relative difference between SMS-RUTF and PM-RUTF is the same.

Delivery to final market contributes more than when manufactured in Africa but less than when manufactured in the USA.

Again, the SMS-RUTF has a lower CO_2e impact per tonne in terms of ingredients, delivery of the goods and packaging for similar reasons as explained in the previous scenarios.

PM RUTF made in France versus SMS RUTF made in Africa

Figure 7 shows the difference in impacts of the two RUTF alternatives with PM-RUTF being manufactured in France and SMS-RUTF in Africa.

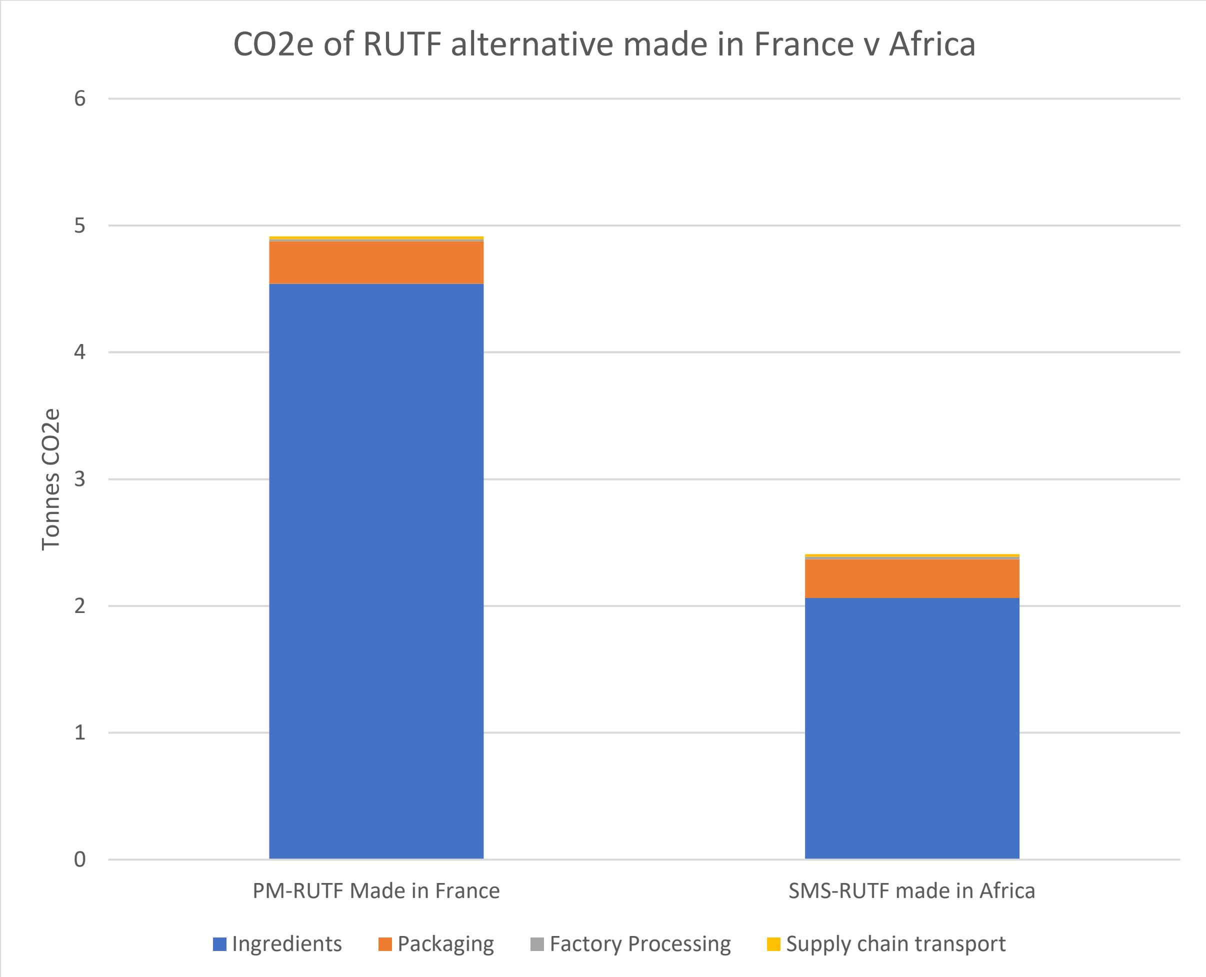


Figure 7 – Climate Impacts of PM-RUTF made in France versus SMS RUTF made in Africa

In this comparison, we see a similar pattern to the other scenarios.

The SMS-RUTF manufactured in Africa has a low GWP impact with the total difference in this case being a 53% reduction, which is similar to other scenarios considered in this report.

There are some differences however, as the processing impacts in France are lower (due to lower GWP for grid electricity). The relative impacts of the PM-RUTF vs SMS-RUFT are shown in Table 15.

Table 15 – Climate Impacts of PM-RUTF made in France and SMS-RUTF made in Africa

	PM-RUTF Made in France	SMS-RUTF made in Africa	Relative Impact
Ingredients	4.54018	2.06301	55%
Packaging	0.336366	0.304714	9%
Factory Processing	0.015681	0.020908	-33%
Supply Chain Transport	0.023147	0.027014	-17%
Delivery of Product to Final Market	0.295758	0.019267	93%
Total CO_2e (tonnes)	**5.211131**	**2.434912**	**53%**

Air Freighting Finished Packaged Product to Africa versus Local Manufacture

A final comparison which considered just transportation was assessed. The GWP impacts of transporting finished packaged RUTF from France via Air Freight (in the case of high demand and short timescales) was compared to making the product locally and having minimal road transportation.

The impacts of this transport are affected by weight, distance travelled, and mode of transport used. The weight of the product and the packaging is the same for SMS-RUTF and PM-RUTF, so the result stands for both types.

The calculated journey stages and calculated carbon impacts per tonne of packed RUTF are:

Table 16 – Climate Impacts transporting finished RUTF products into Africa from other countries via Air Freight

	From France (km)	From USA (km)
Manufacturer to Airport	190	110
Airport to Airport (arrival in Zimbabwe)	8,033	13,500
Road transport from Zimbabwe to Malawi	828	828
Total CO_2e (tonnes)	**4.808**	**8.006**

By manufacturing locally in Africa, this CO_2e from transportation would be saved when compared to shipping in via air freight.

Summary & Conclusion

In summary, the following observations can be made in respect of the GWP impacts of the SMS-RUTF versus the PM-RUTF:

- Overall GWP impacts (including ingredients, processing, packaging, and transport) of the SMS-RUTF is between 47% and 51% lower than that of PM-RUTF.
- The largest contributor of GWP impacts were the ingredients used in both products, with 74-85% for SMS-RUTF and slightly higher proportions of 86-92% for the PM-RUTF.
- The lowest GWP per tonne of product is for the SMS-RUTF manufactured in Africa.
- The highest GWP per tonne of product is for the PM-RUTF manufactured in the USA.
- The raw ingredients used in the SMS-RUTF have a much lower GWP impact (45% less) than the PM-RUTF per tonne of product produced.
- The highest GWP per tonne of any of the raw ingredients is the dried milk powder used in the PM-RUTF.
- The need to source the dried milk powder in Europe when manufacturing in Africa means that the transport impacts are higher per tonne of final product for PM-RUTF manufactured in Africa than the SMS-RUTF alternative.
- Almost all ingredients for the SMS-RUTF product could be sourced locally rather than relying on imports from outside the African continent.
- The SMS-RUTF uses 28% less plastic packaging in the supply chain.

The largest impacts for both the SMS-RUTF and PM-RUTF are the ingredients. When manufactured in Africa, the second highest impact is final product packaging whereas when manufactured in both the USA and France, the second highest impact is the transportation of the product to Africa.

Processing impact varies across the three separate locations, due to the different CO_2e impacts for grid electricity in those countries. France is the lowest, and the USA the highest. However and overall, the processing only contributes lesser amounts, so these differences do not lead to larger variations in the total GWP impacts.

Although several assumptions and estimations have been made in this assessment (due to limitations in availability of information and data), the vast majority of the relevant impacts were included in the calculation. The overall result for the total GWP impacts of each RUTF alternative clearly shows that the SMS-RUTF has a considerably lower total CO_2e, being approximately 50% of the total CO_2e of PM-RUTF.

In a Randomised Controlled Efficacy Trial undertaken in Malawi in 2016, it took an average of 3.2 additional days of treatment (equating to a prudent/worst-case scenario average of 8% more product) with SMS-RUTF to achieve recovery based on weight gain, and the child was then also found to be iron replete and non-anaemic upon discharge. The PM-RUTF recipe did not achieve this important result on iron status upon discharge three days earlier. Therefore, and even applying this increase to SMS-RUTF, the advantage over PM-RUTF on all key criteria remains significant.

Notwithstanding this, the difference in calculated CO_2e is large enough to be able to confidently say that the SMS-RUTF has a substantially lower climate impact than the PM-RUTF.

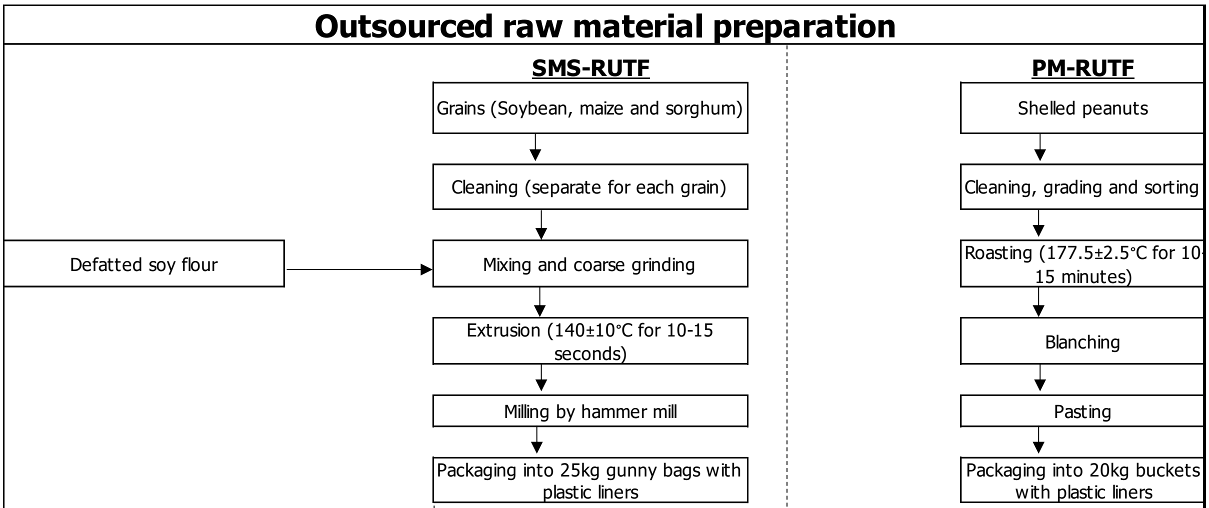
Other Observations / Comments

SMS-RUTF product obviates the requirement for African producers to import skimmed milk powder as the recipe uses more locally available ingredients.

Local manufacture can help to create jobs and support the local economy, bringing wider benefits to society.

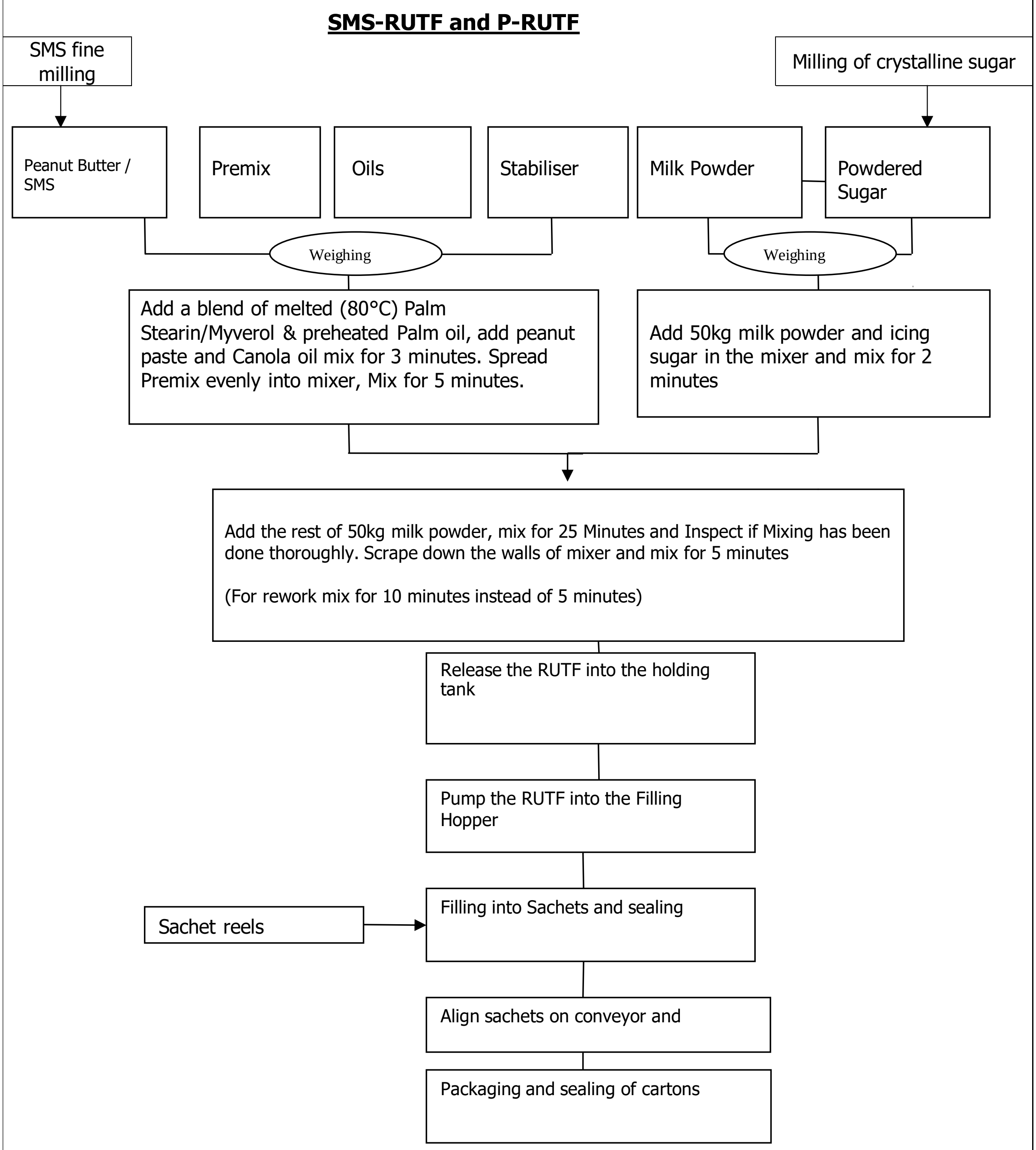
Appendix 1

Flowcharts showing the raw materials and processing steps used for each of the RUTF alternatives. Where available, information was obtained from Valid Nutrition (VN) for their current processes.



Approx material losses, % w/w	SMS-RUTF	PM-RUTF
Cleaning (+ grading & sorting)	5	8.5
Extrusion and milling	3	n/a
Roasting, blanching and pasting	n/a	15
Total	8	23.5

Process steps within VN factory



Overall loss within VN factory		%		%
	SMS-RUTF	2.5	PM-RUTF	2

Appendix 2

Datasets used in the calculation of climate impacts.

Ingredients	EcoInvent 3.8 Datset Used
Canola Oil/Rapeseed Oil	market for rape oil, crude, RoW
Defatted Soy Flour	market for soybean, RoW
Dry Skim Milk	market for skimmed milk, from cow milk, GLO
Maize	market for maize grain, RoW
Micronutrients Premix	No Data
Micronutrients Premix Total (Micronutrient + Crystalline AA)	No Data
Palm Oil	market for palm oil, refined, GLO
Palm Stearin	Modelled as Palm Oil, Crude - Market for Palm Oil, Crude, Glo
Peanut	market for peanut, GLO
Peanut Paste	See Below
Sorghum	market for sweet sorghum grain, GLO
SoyaBean	market for soybean, RoW
Stabilizer (diglycerides)	No Data
Sugar	market for sugar, from sugar beet, GLO

Peanut Butter

Life cycle assessment of greenhouse gas emissions associated with production and consumption of peanut butter in the U.S.

Article in Transactions of the ASABE (American Society of Agricultural and Biological Engineers) · January 2014

Processing Steps

Energy Use in Malawi Facility – information provided by Valid Nutrition.

Energy used to process and extrude grains:
Economic and environmental analysis of extrusion processing of grains into foods and feeds.
Hillary Kletscher, Jacob Venner, Xin Jiang, Kurt A. Rosentrater
Written for presentation at the 2014 ASABE and CSBE/SCGAB Annual International Meeting Sponsored by ASABE. Montreal, Quebec Canada July 13 – 16, 2014

And

Grinding Effect on Whole Sorghum Extrusion Performance and Products.
D. Acosta, M Banon, M Riaz, C. McDonough, R.D. Waniska and L.W. Rooney.

Energy Impacts

Electricity (Processing)	Dataset Used for CO2e per kWh
Africa	https://ourworldindata.org/energy/country/malawi
France	https://ourworldindata.org/energy/country/malawi?country=~FRA
USA	https://ourworldindata.org/energy/country/malawi?country=~USA

Appendix 3

Data used to calculate distances travelled during supply chain and associated impacts of transportation.

Distances:

Distances	Sites Used for Calcualtions
Air	https://www.distance.to/
Road	www.googlhttps://www.google.com/maps
Sea	https://sea-distances.org/

Transportation Impacts:

Taken from the Global Logistics Emissions Council (GLEC) Framework.

Transport Emissions	GLEC 2020 Framework Datasets
Air	GLEC Air freighter long haul (>3700km) ICAO/IATA RP1678
Road	GLEC EU/South America generic HGV
Sea	GLEC General Cargo 10–20 dwkt Average between HFO and MGO

Appendix 4

Complete compilation of datasets and sources used throughout the study.

Topic	Source Used
Ingredients	
Soya Beans	Ecoinvent
Maize	Ecoinvent
Sorghum	Ecoinvent
Defatted Soy Flour	Ecoinvent
Peanut Paste	Ecoinvent
Dry Skim Milk	Ecoinvent
Palm Oil	Ecoinvent
Palm Stearin	Ecoinvent
Canola Oil/Rapeseed Oil	Ecoinvent
Sugar	Ecoinvent
Stabilizer (diglycerides)	Ecoinvent
Micronutrients	Ecoinvent Data sourced from VN
Crystalline Amino Acids	Ecoinvent
Transport	
Air - Distance	distance.to
Road - Distance	Google Maps
Sea - Distance	sea-distance.org
Air - Impacts	GLEC Air Freighter long haul
Road - Impacts	GLED EU/South America Generic HGV
Sea - Impacts	GLEC General Cargo 10-20 dwkt
Energy	
Africa	Our World in Data - Malawi
France	Our World in Data - France
USA	Our World in Data - USA
Processing Steps	
Energy Use in Facility	Provided by VN
Energy Use - Grains	Economic and environmental analysis of extrusion processing of grains into foods and feeds Kletscher, H., Venner, J., Jiang, X., Rosentrater, K.A. Montreal, Quebec Canada July 13 – July 16, 2014 doi: 10.13031/aim.20141904805

Energy Use - Grains	Grinding Effect on Whole Sorghum Extrusion Performance and Products. Acosta, D., Banon, M., Riaz, M., McDonough, C., Waniska, R. D., and Rooney, L. W., 2003, http://crsps.net/wp-content/downloads/INTSORMIL/Inventoried%209.6/3-0000-5-660.pdf
Life Cycle Assessment Approach	
Life Cycle Assessment	When and how much to invest? Investment and capacity choice under product life cycle uncertainty Lukas, E., Spengler, S.S., Kupfer, S., Kiechafer, K. European Journal of Operational Research Volume 260, Issue 3, 1 August 2017, Pages 1105-1114
	ISO 14044 Environmental management — Life cycle assessment — Requirements and guidelines

Appendix 5

Main critical review comments. NB These comments have been addressed in this version of the report. A full copy of the critical review report is held on file.

Evaluation of the report "Plant-based Ready-to-Use Therapeutic Food: Environmental Assessment – Carbon Footprint" prepared by Clearstream Solutions for Valid Nutrition on March 2022

PREPARED BY PROFESSOR NICHOLAS M. HOLDEN, UNIVERSITY COLLEGE DUBLIN FOR VALID NUTRITION ON 13TH MAY 2022

General Observations

The report is quite well written and reasonably thorough, but there are some points of clarification that would make it stronger with regard to its intended purpose.

This evaluation therefore focused on what could be perceived as shortcomings and weaknesses rather than praising the strengths. The evaluation adopts a critical tone, of the kind that could be used for both explicit criticism and general undermining of confidence in the content.

There are four main issues that need attention:

1. The function and functional unit needs to be properly described. It seems most likely that there is functional equivalence between the products, but this needs to be made crystal clear for the reader and must be unambiguously captured in the definition of the functional unit.
2. The system boundary needs to be made unambiguous. For the upstream, it is not entirely clear whether the data used for the ingredients of the RUTF products are system process data that include all impacts from planting, through husbandry to harvest, post-harvest processes and primary processing to the form of the ingredient. A statement to confirm that all data extend to (and do not exceed) the intended upstream system boundary might be useful. Likewise, the downstream boundary is unclear. It appears to be a point of distribution, but what this means does not seem to be the same for all scenarios. It is also probably not meaningful to use to 'Africa' as the end point. A specific location in Africa should be the downstream boundary for all scenarios.
3. The impact category and method used should be stated. The mixing of 'carbon footprint' and 'global warming potential' create confusion and undermine confidence in the report. The impact category should be 'climate change' or 'climate impact' and the impact method used should be stated clearly.
4. The interpretation should be thorough. The evaluation required by the ISO standard should not be ignored completely. To give the reader full confidence in the study, there should be an assessment of completeness, data quality (pedigree), sensitivity and uncertainty.