Documentation of calculations of greenhouse gas emissions of Lofotprodukts fish burger products compared to meat-based burgers

Yannic Wocken, Thomas Angervall, August Larsson, Friederike Ziegler

RISE Research Institutes of Sweden, March 2022

Goal: To quantify greenhouse gas emissions of two Lofotprodukt fish burgers "Lofotburger Torsk & Sei" and "Hjemmelagde Fiskekaker" and compare these with meat-based products.

Functional unit: 1 kg of product transported from factory to Oslo

System boundaries: Production of supply materials for fisheries and agriculture, fisheries and agriculture production, primary and secondary processing, and distribution to Oslo.

Cod (*Gadus morhua*), saithe (*Pollachius virens*) and haddock (*Melanogrammus aeglefinus*) mainly originate from a fishery in north-east Norway, from where they are transported by truck to Leknes. Greater Argentine (*Argentina silus*) is fished and processed to frozen mince in the Faeroe islands which is shipped to the Lofotprodukt factory in Leknes, Norway. At the factory, fillets are minced, mixed with other ingredients, fried and packed, before being trucked to Oslo.

The meat products are modelled based on traditional, Norwegian recipes. The same emissions for processing are assumed for the kjøttkake and the two fish products. The beef hamburger is assumed to have 70% lower processing emissions compared to the other products due to the final product being raw. The production is assumed to take place close to Oslo. All meat is assumed to be of Norwegian origin.

Ingredients of all four assessed products

"Hjemmelagde Fiskekaker":

> Haddock fillet, milk, potato sticks, water, onion, butter, salt, nutmeg, white pepper, carrageenan

"Lofotburger":

> Haddock fillet, cod fillet, greater Argentine mince, saithe fillet, ricemilk powder, water, potato flour, olive oil, salt, onion, potato flakes, Dijon mustard, garlic purée, nutmeg, celery salt, white pepper, carrageenan

"Kjøttkaker"*:

> Beef, pork, egg, onion, cooked potatoes, milk, salt, pepper, ground ginger, butter (for frying)

Hamburger*:

> Beef, potato starch, water, salt, pepper, butter (for frying)

*following the recipes "Hamburgere/Karbonader" and "Svigermors kjøttkaker" from "Den rutede kokeboken" by Espelid Hovig

Allocation: Co-product allocation of Greater Argentine, cod, saithe and haddock fillets was based on mass between the fillet and the commercially used by-products based on mass. The climate database contains values for products using both mass and economic allocation.

Impact assessment: GWP 100 years following IPCC 2013 impact factors

Data sources:

Norwegian fisheries for cod, saithe and haddock were modelled, based on fuel use data from Winther et al. 2020 but using the suppliers to Lofotprodukt in terms of fishing methods/segments and landing sites (which affects the transport distance to Leknes), see Table 1. When fleet segment was not known, demersal trawl was assumed, as a worst-case assumption.

Table 1 Lofotprodukts sourcing of whitefish during 2021. Fuel use is given as average and range (in brackets).

Species	**Demersal trawlers**	**Ocean-going conventional**	**Coastal conventional**	**Edible yield from live weight (%)**	**Proportion of by-products further utilized (%)**	**Greenhouse gas emissions (kg CO_2e/kg edible)**
Cod	0.6%	53%	42%	30,8	60	0.77
Saithe	-	52%	48%	33	60	0.77
Haddock	32%	35%	33%	31,7	60	1.0
Fuel use[1] (l/kg)	0.35 (0.22-0.51)	0.23 (0.2-0.29)	0.09 (0.02-0.17)			

[1]Winther et al. (2020) Greenhouse gas emissions

Fuel use intensities were modelled in LCA software SimaPro (MultiUser version 9.2.0.2) for the specific sourcing pattern of Lofotprodukt, converting fuel use in the fishery to fisheries greenhouse gas emissions using conversion factors from Drivkraft Sverige and a diesel production process from ecoinvent v3.7.1 (total: 2.93 kg CO_2e/l diesel).

For Greater Argentine mince, data on fuel use in the fishery, energy use and sources in processing, product yield and logistics was collected from the Faeroese fishery and primary processor. Transport modes and distances were decided jointly. Fuel use intensity in pelagic pair-trawling was on average 0.29 l/kg in 2021, the edible yield of Greater Argentine is 42% and by-products were fully utilized. Four out of six vessels supplying data used R507 as coolant, a potent mix of greenhouse gases, but emissions were minor. Greenhouse gas emissions were calculated to 0.97 kg CO_2e/kg product at export storage facility on the Faroe Islands.

Background data for energy sources and packaging materials were taken from ecoinvent v3.7.1 Data for road transports (average size trucks 16-24 tons and 90% loaded, no return trips) were taken from the database Network for Transport Measures (NTM). NTM was selected due to better representativity for Nordic conditions and possibilities to adjust the data to specific conditions. For refrigerated truck transports, a 15% addition was applied. Transport by ship was based on ecoinvent v3.7.1 data (Containership transport, reefer container, frozen).

Data for ingredients other than fish was taken from the RISE climate database (Norwegian version, v 2.0)

Lofotprodukt provided data (energy use, use of raw materials and production) for their production in Leknes, Norway in 2020 (Table 2).

Table 2 Processing inputs in the Leknes Factory (per kg product produced)

INPUT TYPE	SPECIFICATION	AMOUNT	UNIT
ELECTRICITY	Norwegian electricity mix	0.88	kWh
COOLANT	R744 (CO_2)	0.00055	kg
GAS FOR HEATING	Propane	0.035	kg
WATER	-	0.724	l

Table 3 Assumed origin of ingredients and transport distance to processing (km)

INGREDIENT	ASSUMED ORIGIN	ASSUMED DISTANCE
BEEF	Norway average	500
PORK	Norway average	500
EGG	Norway average	500
ONION	Central Europe	1800
BOILED POTATO	Norway average	500
MILK	Norway average	500
POTATO STARCH	Europe	1800
SALT	Europe	1800
PEPPER	Europe	1800
GROUND GINGER	Europe	1800
BUTTER	Norway average	500
COD FILLET	Norway	1200
HADDOCK FILLET	Norway	1200
SAITHE FILLET	Norway	1200
GREATER ARGENTINE MINCE	Norway (Faroe islands)	1220
MILK	Norway, Harstad	240
POTATO STARCH	Norway, Oslo	1200
POTATO MEAL	Norway, Oslo	1200
POTATO FLAKES	Norway, Oslo	1200
ONION	Poland/China/USA	Boat + truck, average impact
BUTTER	Norway, Harstad	240
RICE MILK POWDER	Pakistan	Boat + truck, average impact
DIJON MUSTARD	Sweden	1300
GARLIC PUREE	Spain	4500
MUSKAT	Indonesia	Boat + truck, average impact
CELERY SALT	Germany	2400
WHITE PEPPER	Norway, Oslo	1200
SALT	Denmark	1800
OLIVE OIL	Spain	4500
WATER	Local	0
CARRAGEENAN	Spain	4500