

Theme 3 "At the shops"
Further information and references
sheet 1 of 3, for [TakeABiteAtHome](#)



TAKE A BITE OUT OF
CLIMATE CHANGE

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WORK-IT-OUT WORKSHEET REFERENCES FOR FACTS

- Did you know "Soft fruits, like strawberries, are flown across the world so we can eat them fresh in the winter, which contributes to climate change." Read all the details about how fruits contribute to climate change from the original research paper by Angelina Frankowska (Takeabitecc Team member) and colleagues <https://doi.org/10.1016/j.jenvman.2019.06.012>
- Did you know "A thin plastic film (weighing just 1.5 grams) makes cucumbers last for 14 days longer!". The film causes 4.56 gCO₂e for 1.5g of LDPE film while growing a cucumber emits 696 gCO₂e for one cucumber (300g)
 - Dora and locovidou: <https://theconversation.com/why-some-plastic-packaging-is-necessary-to-prevent-food-waste-and-protect-the-environment-117479>
 - Main source here: <http://www.packagingfedn.co.uk/images/reports/Packaging%20in%20Perspective%20-%20November%202008.pdf>
 - LDPE (low density polyethylene) packaging film: 3.04 kg CO₂e/kg product from Ecoinvent 3.6 Database.
 - Cucumber emissions from Frankowska et al. 2019 <https://doi.org/10.1016/j.scitotenv.2019.04.424>

WORK-IT-OUT WORKSHEET REFERENCES FOR NUMBERS

- "Growing and selling a large handful (80g) of fresh strawberries causes 140 grams of greenhouse gases (gCO₂e)". Growing and storing fresh strawberries in the UK causes about 2.23 kg CO₂e / kg strawberries - from Figure S32 "The environmental impacts of UK strawberries by product category" of <https://doi.org/10.1016/j.jenvman.2019.06.012>, of which 1.7 kg CO₂e / kg are from farm and retail (we ignore transport and waste here). 1.7 kg CO₂e / kg strawberries is the same as 1.7 gCO₂e / g strawberries. Therefore 80g of local fresh strawberries causes 1.7 gCO₂e / g strawberries * 80g strawberries = 1.7 * 80 gCO₂e = 136 gCO₂e, which we round to 140 gCO₂e in the worksheet.
- "A lorry might travel 250 miles across the UK, causing 4 grams of CO₂e for 80g of strawberries." Trucks cause about 0.05 kg CO₂e / kg for a 400 km journey. This comes from DEFRA 2018 <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2018>), using their number of 0.133 kg CO₂e / tonne km for HGV refrigerated all diesel, average load. To get the value for 400 km for 1 kg of food we need to multiply by 400 km and divide by 1000 kg per tonne i.e. 0.133 kg CO₂e / tonne km * 400 km / 1000 kg / tonne = 0.133 * 400 / 1000 kg CO₂e / kg = 0.0532 kg CO₂e / kg of produce. This is the same as 0.0532 g CO₂e / g produce, which we round to 0.05 gCO₂e / g. Therefore 80 grams of food cause 80 g * 0.05 gCO₂e / g = 80 * 0.05 gCO₂e = 4 gCO₂e.
- "An aeroplane from Morocco might fly 1500 miles to the UK, causing 280 gCO₂e for your 80 gram portion." Based on DEFRA 2018 Transport emissions factors https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/726911/2018_methodology_paper_FINAL_v01-00.pdf 0.7640 kg CO₂e / tonne / km (long haul dedicated cargo flights, table 40).

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WORK-IT-OUT WORKSHEET REFERENCES FOR NUMBERS

This needs to be multiplied by a radiative forcing factor of 1.9 because of the higher impact of emissions at altitude - however note that this factor is not well known. So 1 kg of food transported 10000 km causes $(0.764 \text{ kg CO}_2\text{e} / \text{tonne} / \text{km}) * 1.9 * (10000 \text{ km}) / (1000 \text{ kg} / \text{tonne}) = 0.764 * 1.9 * 10000 / 1000 \text{ kg CO}_2\text{e} / \text{kg} = 14.5 \text{ kg CO}_2\text{e} / \text{kg} = 14.5 \text{ gCO}_2\text{e} / \text{g}$. London to Marrakech is 2300 km (about 1500 miles). 1500 miles is $1500 * 8/5 = 2400 \text{ km}$. Transporting 80 grams of food 2400 km causes $80 \text{ g} * 14.5 \text{ gCO}_2\text{e} / \text{g} * 2400 \text{ km} / 10000 \text{ km} = 80 * 14.5 * 2400 / 10000 \text{ gCO}_2\text{e} = 278 \text{ gCO}_2\text{e}$, which we round to 280 gCO₂e. We have assumed the same emissions for growing strawberries in the UK as in Morocco (before considering transportation).

- “A boat brings bananas from the other side of the world, causing 26 gCO₂e for one small (100g) banana.” DEFRA 2018
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/726911/2018_methodology_paper_FINAL_v01-00.pdf gives 0.01308 kg CO₂e / tonne / km for refrigerated cargo. E.g. for a 20000 km trip, we need to multiply by 20000 km and divide by 1000 kg / tonne (to get a result per kg of food) which gives $0.01308 \text{ kg CO}_2\text{e} / \text{tonne} / \text{km} * 20000 \text{ km} / (1000 \text{ kg} / \text{tonne}) = 0.01308 * 20000 / 1000 \text{ kg CO}_2\text{e} / \text{kg} = 0.26 \text{ kg CO}_2\text{e} / \text{kg} = 0.26 \text{ gCO}_2\text{e} / \text{g}$. So a 100g banana brought 20000 km causes $100 \text{ g} * 0.26 \text{ gCO}_2\text{e} / \text{g} = 26 \text{ gCO}_2\text{e}$.
- “Growing a banana causes 40 gCO₂e” - this comes from <https://doi.org/10.1016/j.jenvman.2019.06.012> 1.3 kg CO₂e / kg for bananas, of which 67% is transport and waste. We subtract off their transport and waste value to avoid double counting, so we use $1.3 \text{ kg CO}_2\text{e} / \text{kg} * (1-0.67) = 0.43 \text{ gCO}_2\text{e} / \text{g}$. For a 100g banana this causes $100 \text{ g} * 0.43 \text{ gCO}_2\text{e} / \text{kg} = 43 \text{ gCO}_2\text{e}$, which we round down to 40 gCO₂e. We have ignored the weight of the banana skin in the transport calculation, if we consider the weight of the banana flesh to be 100g.

BONUS CHALLENGE WORK-IT-OUT WORKSHEET

- “1 gram of beef causes 46 grams of greenhouse gas emissions (gCO₂e)” See the references document for Theme 2 for more details on where this number comes from.
 - So $46 \text{ gCO}_2\text{e} / \text{g beef} * 100 \text{g beef} = 46 * 100 \text{ gCO}_2\text{e} = 4600 \text{ gCO}_2\text{e}$. Truck for 400 km: $0.05 \text{ gCO}_2\text{e} / \text{g beef} * 100 \text{g beef} = 0.05 * 100 \text{ gCO}_2\text{e} = 5 \text{ gCO}_2\text{e}$. Thus, the GHG emissions of beef transported by truck in the UK (400km) is: $4600 \text{gCO}_2\text{e} + 5 \text{gCO}_2\text{e} = 4605 \text{gCO}_2\text{e}$
 - In the case of transporting by ship: we considered a trip by ship from “the other side of the world” as 20000 km away from the UK, which means $0.26 \text{ kg CO}_2\text{e} / \text{kg of food}$ or $0.26 \text{g CO}_2\text{e} / \text{g of food}$. So for 100 of beef the emissions of shipping is $26 \text{g} (0.26 \text{g CO}_2\text{e} / \text{g of beef} * 100 \text{g beef} = 0.26 * 100 = 26 \text{g CO}_2\text{e})$ which in total adds up: $4600 \text{g CO}_2\text{e} + 26 \text{g CO}_2\text{e} = 4626 \text{g CO}_2\text{e}$
 - Technically the beef emissions number already includes the transportation, but this is only approximately $0.6 \text{ gCO}_2\text{e} / \text{g}$ (see Poore & Nemeck 2018 “full database” available from <https://josephpoore.com/>) out of the $46 \text{ gCO}_2\text{e} / \text{g}$ so we ignore this double counting as it makes little difference to the results. Also this correction is small compared to the range of emissions for beef.
 - e.g. here we have used the value for greenhouse gas emissions for raising cows in Europe (see references sheet for Theme 2 for a discussion), so the result above corresponds to transporting European beef to the other side of the world.
 - To calculate the emissions for beef raised in Latin America and eaten in the UK we should use a different value for the emissions from raising beef, for example we might use the value for Latin America of $179.4 \text{ gCO}_2\text{e} / \text{g}$ (see references sheet for Theme 2 for more details).
 - Either way, the transportation makes a minor difference compared to raising the beef.

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BONUS CHALLENGE WORK-IT-OUT WORKSHEET

- “Growing and cooking beans at home causes about 1 gram of greenhouse gas emissions (gCO₂e) for 1 gram of cooked beans.” The global average emissions for beans and pulses from Poore & Nemeck 2018 is 1.8 kg CO₂e / kg dry beans. Using a rehydration factor of 0.349 from Durlinger et al 2017 this is 1.8 kg CO₂e / kg dry beans * 0.349 g dried beans / 1 g rehydrated beans = 1.8 * 0.349 / 1 kg CO₂e / kg rehydrated beans = 0.62 kg CO₂e / kg rehydrated beans = 0.62 gCO₂e / g rehydrated beans.
- Allowing 5 minutes of cooking time per 200g portion of rehydrated beans, at 2 kW using an energy mix causing 0.5 kg CO₂e / kWh (as used in Theme 1), adds 5 / 60 hours * 2 kW * 0.5 kg CO₂e / kWh * 1000 g / kg = 5 / 60 * 2 * 0.5 * 1000 gCO₂e = 83 gCO₂e for a 200g portion i.e. 83 gCO₂e / 200 g = 83 / 200 gCO₂e / g = 0.42 gCO₂e / g. Adding the beans and the cooking together gives 0.62 gCO₂e / g + 0.42 gCO₂e / g = 1.04 gCO₂e / g for cooked beans, which we round to 1 gCO₂e / g.
 - So, 1 gCO₂e / g cooked beans * 100 g cooked beans = 1 * 100 gCO₂e = 100 gCO₂e beans * 100g beans = 0.05 * 100 gCO₂e = 5 gCO₂e. Thus, the GHG emissions of beans transported by truck in the UK (400km) is: 100gCO₂e + 5gCO₂e = 105gCO₂e.
 - In the case of transporting by ship: we considered a trip by ship from “the other side of the world” as 20000 km away from the UK, which means 0.26 kg CO₂e / kg of food or 0.26g CO₂e / g of food. So for 100 of beans the emissions of shipping is 26g(0.26g CO₂e / g of beans * 100g beans = 0.26 * 100 = 26g CO₂e), which in total adds up: 100g CO₂e + 26g CO₂e = 126g CO₂e.
 - Technically this number already includes the transportation of the beans. Poore & Nemeck 2018 (“full database” available from <https://josephpoore.com/>) uses a value of 0.1 kg CO₂e / kg dried beans for the transport emissions, which modifies our above value to (1.8 - 0.1) * 0.349 / 1 kg CO₂e / kg rehydrated beans = 0.59 gCO₂e / g rehydrated beans. Adding this to the cooking assumed above gives 0.59 gCO₂e / g + 0.42 gCO₂e / g = 1.01 gCO₂e / g for cooked beans. This is the same as the previous value to within the rounding we apply for the worksheet.
 - In the above we have assumed the beans are transported after hydration, however in the more common case of transporting dry beans the numbers would be even lower.

INTERVIEW INFORMATION

- “It takes up to 60 days for an aluminium can to become a can again”. Learn more about aluminium based packaging here: <https://www.european-aluminium.eu/about-aluminium/aluminium-in-use/packaging/#:~:text=It%20takes%20only%2060%20days,target%20for%202025%20and%202030>
- “We need to make sure that once we have consumed the food we dispose of the packaging in the right waste bin”. Niero and Olsen (2016) <https://www.sciencedirect.com/science/article/abs/pii/S0921344916301604>
- “There is no black and white when it comes to decide which is the best packaging alternative”. Boesen et al. 2019 <https://www.sciencedirect.com/science/article/pii/S0959652618334553>

IMAGE CREDIT

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