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Research article

# Understanding the impact on climate change of convenience food: Carbon footprint of sandwiches

Namy Espinoza-Orias, Adisa Azapagic\*

Sustainable Industrial Systems, School of Chemical Engineering and Analytical Sciences, The University of Manchester, Manchester M13 9PL, UK

## ABSTRACT

Sandwiches are ubiquitous food items and yet little is known about their environmental impacts. This paper focused on their impact on climate change and estimated the carbon footprint of commercial and home-made sandwiches. The study also explored how the information on the carbon footprint could be combined with nutritional data to assist consumers in making more informed food choices. In total, 40 different recipes were considered, focusing on most popular consumer choices in the UK. The estimated impact from ready-made sandwiches ranges from 739 g CO<sub>2</sub> eq. for egg & cress to 1441 g CO<sub>2</sub> eq. for the bacon, sausage & egg option. The carbon footprint of the most popular home-made sandwich (ham & cheese) varies from 399–843 g CO<sub>2</sub> eq. per sandwich, depending on the recipe. The average impact from the home-made option is around two times lower than the impact from the ready-made equivalent with the same ingredients. The greatest contributor to the carbon footprint of both types of sandwich is the agricultural production of ingredients; for ready-made sandwiches, the preparation and retail stages are also significant. Various improvement options were considered through 22 scenarios, including changes in the cultivation of ingredients, recipe changes, reduction of food waste, alternative packaging and different waste management options. The findings suggest that reductions in the carbon footprint of up to 50% are possible for ready-made sandwiches. The greatest improvement opportunities lie in reducing post-consumer waste; however, these are most difficult to realise as they involve changing consumer behaviour.

**Keywords:** Carbon footprint; GHG emissions; Food; Life cycle assessment; Lunch; Sandwiches

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## 1. Introduction

The sandwich has become a ubiquitous convenience food item and today it is difficult to imagine times before its invention. The earliest formal mention of this type of food dates back to 1762, when the English historian Edward Gibbon called the “bits of cold meat” *sandwiches*, after John Montagu, 4th Earl of Sandwich who preferred to eat his food in this form so that he could continue playing without leaving the gaming-table (Anonymous, 1989). Today, a sandwich is typically defined as a snack food comprising a filling (sweet

or savoury) enclosed between two or more slices of bread (IFIS, 2009).

More than 11.5 billion sandwiches are estimated to be consumed in the UK, of which approximately half are prepared at home and the remaining half sold as ready-made and usually pre-packaged (BSA, 2017). Consumers paid £7.85 billion for the latter, at an average cost of around £2 per sandwich (BSA, 2017). The most popular ready-made sandwiches include chicken salad bacon, lettuce and tomato (BLT), Ploughman’s cheese and egg & cress (see Table 1). Whereas consumer preference for sandwich fillings fluctuates from

\* Corresponding author.

E-mail address: [adisa.azapagic@manchester.ac.uk](mailto:adisa.azapagic@manchester.ac.uk) (A. Azapagic).

Received 6 April 2017; Received in revised form 6 November 2017; Accepted 4 December 2017; Published online 24 December 2017.

**Table 1 – Favourite sandwich fillings and types of sandwich in the UK (BSA, 2008, 2010).**

Filling	Market share [%]	Type of sandwich	Ranking (with respect to popularity)
Chicken	36.6	Chicken salad	1
Ham	7.6	Prawn mayonnaise	2
Cheese	6.8	Eggs & cress	3
Tuna	5.6	Bacon, lettuce & tomato (BLT)	4
Prawn	5.1	Mixed selection	5
Bacon	5.0	Chicken & bacon	6
Breakfast	4.7	Cheese & onion	7
Cheese	4.5	Tuna & sweetcorn	8
Egg	4.5	Cheese Ploughman's	9
Combination	4.3	Chicken & sweetcorn	10
Other meats	4.2	Salmon & cucumber	11
Salmon	4.1	Ham & mustard	12
Salad/vegetables	2.8	Breakfast	13
Beef	2.4	Ham & Cheddar cheese	14
Other fish/seafood	1.0	Southern fried chicken	15
		Chicken Caesar	16
		Chicken & stuffing	17
		Egg & bacon	18
		Tuna & cucumber	19
		Egg & mayonnaise	20

year to year, there is a strong preference for the standard sandwich bread: 58% of sandwiches are made using square slices (BSA, 2010) over non-traditional alternatives such as tortilla wraps, bread rolls or baguettes. With regard to home-made sandwiches, though, consumer surveys indicate that the favourite fillings are ham and cheese (BSA, 2010). This would imply that apart from food left-overs used to prepare lunchbox sandwiches, ham and cheese tend to be the typical ingredients for sandwich making found at home.

Given that sandwiches are a staple component of the British diet as well as their significant market share in the food sector, it is important to understand the contribution from this sector to the emissions of greenhouse gases. Therefore, the aim of this work is to estimate the carbon footprints of a range of typical UK sandwich varieties, prepared both commercially and at home. The paper also explores how the information on the carbon footprint could be combined with nutritional data to assist consumers in making more informed food choices. As far as the authors are aware, this is the first study of its kind.

## 2. Methods

The methodology used to estimate the carbon footprints of sandwiches follows the ISO 14040/44 (ISO, 2006a,b) and PAS 2050:2011 (BSI, 2011) standards. The following sections discuss the methodological approach, assumptions and data used in the study.

### 2.1. Goal of the study

The main goals of the study are:

- to calculate the GHG emissions arising in the life cycle of most popular ready-made and home-made sandwiches prepared and consumed in the UK; and
- to identify the carbon 'hot spots' and opportunities for improvements.

The functional unit is defined as "one individual sandwich serving, consisting of two slices of bread and a filling, prepared and ready for consumption", representing one serving.

### 2.2. Types of sandwich

Two general types of sandwich are considered: ready-made and home-made; their compositions are detailed in Tables 2–5, based on own market research.

For the commercial ready-made sandwiches, a total of 24 recipes are considered; for details see Tables 2–4. These were chosen based on the consumer preferences and also guided by data availability for the ingredients. The recipes are grouped in four categories, depending on the main ingredients: pork meat; chicken meat; fish and prawns; and cheese and eggs (vegetarian). The number of ingredients used in each sandwich recipe is relatively small — four on average, with mayonnaise being common to all but two recipes. Other most commonly used ingredients include bacon, ham, cheese and tomato. The mass of the sandwiches ranges from 128 to 199 g, with bread accounting for almost half of the total mass. In turn, the energy content of the sandwiches ranges from 279 up to 546 kcal (1169–2286 kJ).

For home-made sandwiches, a total of 16 variations on the recipe for ham & cheese sandwich were considered. The ingredients used in this type of sandwich are assumed to be readily available in any home refrigerator and are ready to be used without any further processing or preparation. In this case, just one recipe was selected because the availability of ingredients at home (including not only fresh ingredients but also food left-overs) combined with the tastes and preferences of the person preparing the sandwich gives rise to a number of potential recipes that cannot be assessed exhaustively within the scope of this study without making too many assumptions. Whereas commercial recipes are standardised, consistency in home-made recipes for sandwiches cannot be assumed to be the norm.

The ingredients considered for home-made ham & cheese sandwiches are bread, ham, cheese and mayonnaise. The

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