

Understanding the Carbon Footprint of Meals

Benchmarks and the Context Problem

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Introduction

The global food system accounts for between 25-30% of human-caused greenhouse gas emissions.¹ As individuals seek to reduce their environmental impact, understanding the carbon footprint of individual meals has become increasingly important. However, meal-level carbon footprints vary dramatically: a veggie burrito might generate 355g CO₂-equivalent (CO₂e), while a beef burrito with cheese and sour cream produces 3,493g CO₂e—nearly ten times higher.²

This variation creates a challenge: without clear benchmarks, consumers cannot determine whether a given meal's footprint is high, low, or somewhere in between. A number like '1,200g CO₂e' is meaningless without context. This white paper establishes research-backed benchmarks for meal carbon footprints and addresses a critical design challenge in creating tools that help people make more sustainable food choices.

Benchmarks: What's a Sustainable Meal?

Daily and Annual Targets

Research has established several thresholds for sustainable dietary carbon footprints. The Harvard Foodprint Calculator identifies 680kg CO₂e per year as the upper limit of a sustainable diet.³ This translates to approximately 1,863g CO₂e per day, or roughly 620g per meal assuming three meals daily.

The Paris Climate Accord established a more lenient target: to meet emissions reduction goals, the United States aimed to reduce per capita food-related emissions to 2,764g CO₂e per person per day.² This equals approximately 921g per meal. While higher than the sustainable threshold, this represents a significant reduction from current American dietary patterns.

Actual Diet Footprints

To provide context, current dietary patterns show substantial variation. A meat-lover diet produces approximately 3,300kg CO₂e annually—more than four times the sustainable threshold.⁴ A vegetarian diet

roughly halves this footprint to 1,650kg per year, while a vegan diet achieves 1,500kg annually, just above twice the sustainable target.⁴

International comparisons reveal even greater variation. Analysis of national dietary guidelines found that India's recommended diet produces just 0.86kg CO₂e per day (287g per meal), while United States dietary guidelines result in 3.83kg CO₂e daily (1,277g per meal)—4.5 times higher.⁵

Concrete Meal Examples

UCLA's carbon footprint research provides specific meal comparisons:²

Meal	CO ₂ e (grams)
Beef burrito (beef, cheese, sour cream, rice)	3,493
Impossible™ burrito (plant-based meat, guacamole, rice)	581
Veggie burrito (beans, guacamole, rice)	355

These examples illustrate the dramatic range in meal footprints and demonstrate that ingredient choice—particularly the presence or absence of animal products—is the primary driver of variation.

Key Drivers

Research consistently shows that ingredient choice dominates meal carbon footprints. Beef production generates approximately 60kg CO₂e per kilogram of product, while peas produce just 1kg CO₂e per kilogram—a 60-fold difference.⁶ Animal-based foods generally have higher footprints due to land use change, methane emissions from ruminants, and the resource intensity of feed production. Notably, transportation accounts for less than 5% of most foods' carbon footprints, meaning that ingredient selection matters far more than food miles.⁶

The Meal Type Challenge

The Problem: Why Absolute Thresholds Can Mislead

Establishing absolute carbon footprint thresholds for meals—such as labeling anything under 700g as 'low carbon'—appears straightforward but creates significant interpretation challenges. Consider two scenarios:

A chocolate cake dessert serving produces 400g CO₂e. Using absolute thresholds, this would be rated 'low carbon' and displayed with a green indicator. However, this is misleading: 400g is actually quite high for a dessert, which typically represents a small portion of daily caloric and carbon budget.

Conversely, a large vegetable stir-fry dinner might produce 1,200g CO₂e—rating it 'medium' or even 'high carbon' by absolute standards. Yet compared to other dinner options, particularly those featuring meat or cheese, this represents a relatively low-carbon choice for a main meal.

This mismatch occurs because absolute thresholds ignore meal context. Different meal types serve different nutritional and social functions, with corresponding differences in typical portion sizes and carbon footprints. Applying uniform thresholds across all meal categories provides users with technically accurate but practically misleading information.

The Solution: Category-Specific Ratings

A more useful approach compares meals within their categories. Instead of asking 'Is 400g CO₂e high or low in absolute terms?', the relevant question becomes 'Is this a high- or low-carbon dessert compared to other desserts?' or 'Is this a high- or low-carbon dinner compared to other dinners?'

This category-specific approach employs percentile-based ratings within meal types. For example:

Category	Example Meal	CO ₂ e	Rating Within Category
Dessert	Fruit salad	200g	Low (compared to desserts)
Dessert	Chocolate cake	400g	High (compared to desserts)
Dinner	Vegetable stir-fry	1,200g	Low (compared to dinners)
Dinner	Beef stew	2,500g	High (compared to dinners)

This approach provides actionable information: when choosing a dessert, users can identify lower-carbon options within that category. The rating reflects realistic comparisons and supports informed decision-making.

Implementation Considerations

Implementing category-specific ratings requires sufficient data within each meal category to establish meaningful percentiles. A practical two-phase approach addresses this challenge:

Phase 1: Absolute Thresholds. Initially, when recipe databases are small, absolute thresholds provide immediate utility. Simple traffic-light indicators (Low: <700g, Medium: 700-1,600g, High: >1,600g per serving) give users basic orientation, working from the first recipe entered.

Phase 2: Category-Specific Percentiles. Once sufficient recipes exist in each category (typically 20-50), the system transitions to percentile-based ratings within meal types. Traffic-light indicators now reflect category-specific comparisons: green for the lowest 40%, yellow for middle 30%, red for highest 30% within each meal type.

This phased approach balances immediate functionality with long-term accuracy, ensuring users receive meaningful guidance regardless of database size.

Conclusion

Individual meal carbon footprints span a wide range, from under 300g CO₂e for plant-based meals to over 3,000g for meat-heavy options. The sustainable diet threshold of 680kg CO₂e annually translates to approximately 620g per meal—a target that requires substantial shifts from current dietary patterns in many countries.

However, simply displaying carbon footprint numbers is insufficient. Without context, users cannot interpret whether their choices are sustainable. Absolute thresholds provide some guidance but can mislead when applied uniformly across meal types with different nutritional purposes and typical portion sizes.

Category-specific ratings offer a solution: by comparing meals within their categories, users receive actionable information that supports meaningful dietary decisions. This approach transforms carbon footprint data from abstract numbers into practical guidance, helping individuals reduce their environmental impact while maintaining dietary variety and satisfaction.

The challenge now is not generating carbon footprint data—the science is well-established—but making that data useful. Tools that provide context-aware ratings can empower consumers to make sustainable choices without requiring expertise in lifecycle assessment or climate science. Making carbon data actionable, not merely available, is the path forward.

About Mealprint

This white paper was developed as part of the research and design process for Mealprint, a tool for calculating recipe carbon footprints. Mealprint implements the category-specific rating approach described in this paper.

References

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