

ENVIRONMENTAL, NUTRITIONAL AND COST IMPACTS OF BEEF/LENTIL BLENDED BURGERS

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Environmental, Nutritional and Cost Impacts of Beef/Lentil Blended Burgers

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Numerous studies have shown that replacing a portion of beef with plant-based foods in daily diets can improve health, nutrition and environmental impacts (Willett et al. 2019; Chaudhary & Krishna, 2019; Clune et al. 2018). Lentils are plant-based foods that have both environmental and nutritional benefits. The capacity of lentils to fix atmospheric nitrogen during their cultivation results in reduced nitrogen fertilizer requirement in crop production systems (Clune et al. 2017). Lentils also do not require irrigation and are well suited to semi-arid, water scarce regions (Angadi et al. 2008), and incorporating lentils into crop rotations can improve soils, yield and protein content of the following crop (MacWilliam et al. 2018; Lupwayi et al. 2007). Finally, lentils contain high amounts of protein, fiber, essential vitamins and minerals.

Beef-based burger patties can be made more sustainable, nutritious and cost-effective, while maintaining palatability, by reformulating with a portion of pulses such as whole cooked lentils. However, the nutritional and environmental benefits of lentil-reformulated beef burgers have not been quantified. This study compared the nutritional impact, environmental footprints (carbon, water and land use) and cost of lean US beef burgers compared to lean US beef burgers reformulated with 33% cooked lentil puree. Nutritional data show that partial replacement of lean ground beef with 33% cooked lentil puree results in a burger patty with 12% less calories per serving (4oz or 115 grams), 32% less saturated fat, total fat and cholesterol per serving. The blended lean beef/lentil burger patty also contains 3 grams of fiber serving (compared to 0 grams

in lean burger patty). Reformulation with lentil puree resulted in a decrease in protein content (15% decrease). There is also 26% reduction in cost per serving of the blended lean beef/lentil burger compared to the 100% lean ground beef burger.

The study utilized production and environmental data representing US beef production (Rotz et al. 2019) and the lentil production region of Saskatchewan, Canada. A life cycle assessment (LCA) was conducted to assess the environmental impact of reformulating beef burgers with 33% cooked lentil puree. The carbon footprint, water footprint and land use footprint of the blended beef/lentil burger is 33%, 33% and 32%, respectively, lower than regular 100% US beef burgers.

The results of this study demonstrate that reformulating beef burgers with whole cooked lentils is a strategy that can make a substantial impact on the cost, nutrition and environmental impact of beef burger. The study also demonstrates the importance of using ecosystem specific agricultural production data and characterization factors to obtain accurate results when conducting life cycle assessments of food products.

References

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| Product | Environmental impact factors | | | Assumptions/Source for Greenhouse Gas Emissions | Assumptions/Source for Blue water use | Assumptions/Source for Land Use Footprint | Source link |
|--|------------------------------|---------------------------------|---------------|--|---|---|--|
| | GHG emissions (kg CO2e) | Blue (irrigation) water use (L) | Land use (m2) | | | | |
| Dry lentils, at farm (1 kg) | -0.12 | 0.67 | 6.67 | Canadian Roundtable for Sustainable Crops, Carbon Footprint for Canadian Lentils, 2017 | Blue water footprint of lentils from Fig. 7 of Ding et al. (2018), % irrigation required = 24% of total water demand of lentils, full calculation of water footprint on 'Lentils - water footprint' worksheet | Yield is weighted average of 18 census divisions) | GHG: Pulse Canada has copy of report; Water footprint: https://www.mdpi.com/2073-4441/10/11/1609 ; Land use footprint: http://publications.saskatchewan.ca/#/products/89979 |
| Lentils, cooked (1kg) | 0.28 | 0.29 | 2.87 | 1 kg of dry lentils provide 2.326 kg of cooked lentils. Cooking stage gas use from Dettling et al. 2016. See Appendix M of report on Morningstar Farms website for cooking footprint of pulses | 1 kg of dry lentils provide 2.326 kg of cooked lentils. | 1 kg of dry lentils provide 2.326 kg of cooked lentils. | Pulse Canada; 33. Dettling, J., Tu, Q., Faist, M., DelDuce, A. and Mandlebaum, S., 2016. A comparative life cycle assessment of plant-based foods and meat foods. Quantis USA: Boston, MA, USA.; https://www.morningstarfarms.com/content/dam/morningstarfarms/pdf/MSFPlantBasedLCARReport_2016-04-10_Final.pdf |
| Canadian boneless beef at packers end gate (1 kg) | 24.5 | 508.3 | 196.4 | GHG footprint of Canadian beef from Table 2.28, page 84 of NBSA (2018) report | Water footprint of CDN beef from Table 2.28, page 84 of NBSA (2018) report | Land use of CDN beef from Table 2.28, page 84 of NBSA report) | https://crsb.ca/assets/Uploads/About-Us/Our-Work/NBSA/8e68cb86c3/NBSA-EnvironmentalAndSocialAssessments.pdf |
| US boneless beef at packers end gate (1 kg) | 29.1 | 2220.9 | 86.5 | Table 4 of Rotz et al. (2019) <i>Agricultural Systems</i> (23.3 kgCO2eq. till carcass weight and then 5.8 kg added from carcass to retail gate just like NBSA report does for Canada) | Table 5 of Rotz et al. (2019) <i>Agricultural Systems</i> (bluewater till carcass weight is 2095 Litres and then we add 125.9 litres from carcass to retail stage just like in NBSA Canadian report | Land use of US beef from Nijdam et al. 2012 | https://www.sciencedirect.com/science/article/pii/S0308521X18305675#s0085 ; https://www.sciencedirect.com/science/article/abs/pii/S0306919212000942 |
| One serving of regular ground beef burger (CDN beef) (115 g) | 2.79 | 57.84 | 22.35 | Calculation using regular burger formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using regular burger formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using regular burger formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | |
| One serving of regular ground beef burger with lentil puree (CDN beef) | 1.87 | 38.57 | 14.98 | Calculation using beef burger with lentil puree formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using beef burger with lentil puree formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using beef burger with lentil puree formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | |
| One serving of regular ground beef burger (US beef) | 3.31 | 252.74 | 9.84 | Calculation using regular burger formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using regular burger formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using regular burger formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | |
| One serving of regular ground beef burger with lentil puree (US beef) | 2.22 | 168.45 | 6.65 | Calculation using beef burger with lentil puree formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using beef burger with lentil puree formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | Calculation using beef burger with lentil puree formulation shown in worksheet 'Burger formulations', calculation does not include salt and pepper footprints | |

Environmental impact of substituting in 33% lentil puree in U.S. hamburgers

| | GHG emissions (MT CO2e) | Blue water footprint (billions of US gallons) | Land use footprint (square miles) |
|--|-------------------------|---|-----------------------------------|
| Impact of hamburgers consumed in US, annually ~ 10,000,000,000 burgers | 33.12 | 667.74 | 38006.56 |
| Impact of reformulated burgers, 10,000,000,000 burgers | 22.16 | 445.04 | 25665.68 |
| Environmental impact difference | 10.96 | 222.69 | 12340.89 |
| Environmental impact difference (%) | 33.10% | 33.35% | 32.47% |

| Conversion of environmental impact to relatable numbers | GHG emissions (MT CO2e) | Blue water footprint (billions of US gallons) | Land use footprint (square miles) | Source | Source link |
|---|-------------------------|---|-----------------------------------|--|---|
| Environmental impact difference of reformulating 10,000,000,000 burgers | 10.96 | 222.69 | 12340.89 | | |
| Emissions per average US car per year (tonnes/year) | 4.6 | | | Environmental Protection Agency | https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle |
| Greenhouse gas impact in US cars off the road | 2,382,674 | | | | |
| 2018 automobile registrations for Orange County, California | 2,325,038 | | | California Department of Motor Vehicles Statistics | https://www.dmv.ca.gov/portal/wcm/connect/add5eb07-c676-40b4-98b5-8011b059260a/est_fees_pd_by_county.pdf?MOD=AJPERES |
| Size of Olympic-size pool (US gallons) | | 660000 | | Wikipedia | https://en.wikipedia.org/wiki/Olympic-size_swimming_pool |
| Blue water use impact in # of olympic pools | | 337413 | | | |
| Size of Maryland | | | 12406 | US Census Bureau | https://www.census.gov/geo/reference/state-area.html |

Environmental, Nutritional and Economic Impact Analysis of Blended Burger

Pulse Canada

27-Mar-20

Product Name: Beef Burger (1 serving = 4 oz, 115g)

| Ingredient Name | Quantity | Weight (g) | \$USD/kg | Cost of ingredients | Cost per kg | Cost per serving |
|------------------------|-----------------|-------------------|-----------------|----------------------------|--------------------|-------------------------|
| lean ground beef | 1 lb | 454.0 | \$ 5.79 | \$ 2.63 | | |
| kosher salt | 1 tsp (5 mL) | 6.0 | n/a | | | |
| black pepper | 1/2 tsp (2 mL) | 1.4 | n/a | | | |
| TOTAL | | 461.4 | | \$ 2.63 | \$ 5.69 | \$ 0.65 |

Product Name: Beef Burger with Lentil Puree (1 serving = 4 oz, 115g)

| Ingredient Name | Quantity | Weight (g) | \$USD/kg | Cost of ingredients | Cost per kg | Cost per serving |
|------------------------|-----------------|-------------------|-----------------|----------------------------|--------------------|-------------------------|
| lean ground beef | 1 lb | 454.0 | \$ 5.79 | \$ 2.63 | | |
| raw lentils | | 78.2 | \$ 3.41 | \$ 0.27 | | |
| water | | 45.0 | n/a | | | |
| kosher salt | 1 tsp (5 mL) | 6.0 | n/a | | | |
| black pepper | 1/2 tsp (2 mL) | 1.4 | n/a | | | |
| TOTAL | | | | \$ 2.89 | \$ 4.20 | \$ 0.48 |

26% cost savings

Environmental, Nutritional and Economic Impact Analysis of Blended Burger

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19-Feb-20

| Product | Nutritional factors | | | | | |
|--|---------------------|-------------------|---------------|------------------|---------------|-------------|
| | Calories (kcal) | Saturated fat (g) | Total fat (g) | Cholesterol (mg) | Fiber (g) | Protein (g) |
| lentils, cooked (100 g)* | 156 | 0.15 | 0.55 | 0 | 9.7 | 12.82 |
| lean ground beef (100 g)# | 207 | 5.4 | 13.7 | 60 | 0 | 19.58 |
| One serving of lean ground beef burger (115 g) | 234 | 6.19 | 15.5 | 68 | 0.06 | 22.19 |
| One serving of lean ground beef burger with lentil puree (115 g) | 205 | 4.19 | 10.6 | 46 | 3 | 18.77 |
| % difference between lean burger and blended beef/lentil burger | 12% | 32% | 32% | 32% | -4900% | 15% |

*Nutrient composition data was provided by independent nutrient analysis (Silliker Canada Co., Markham, Ontario Canada) for whole cooked green lentils.

Nutrient composition data for regular ground beef from Canadian Nutrition File (CNF#: 2786)

Environmental, Nutritional and Economic Impact Analysis of Blended Burger

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19-Feb-20

Product Name: Beef Burger with Lentil Puree (1 serving = 4 oz, 115g)

Reference: <https://www.lentils.org/recipe/classic-beef-lentil-burger/>

| Ingredient Name | Quantity | Weight (g) | Weight per serving | Proportion of Recipe % |
|--------------------|----------------|--------------|--------------------|------------------------|
| lean ground beef | 1 lb | 454.0 | 75.8 | 66.0% |
| red lentil, cooked | 1/2 lb | 182.0 | 30.4 | 26.4% |
| water | | 45.0 | 7.5 | 6.5% |
| kosher salt | 1 tsp (5 mL) | 6.0 | 1.0 | 0.9% |
| black pepper | 1/2 tsp (2 mL) | 1.4 | 0.2 | 0.2% |
| TOTAL | | 688.4 | 115.0 | 100% |

Reference: <https://www.lentils.org/recipe/classic-beef-lentil-burger/>

Product Name: Beef Burger (1 serving = 4 oz, 115g)

Reference: <https://www.lentils.org/recipe/classic-beef-lentil-burger/>

| Ingredient Name | Weight per serving | Proportion of Recipe % |
|------------------|--------------------|------------------------|
| lean ground beef | 113.8 | 99.0% |
| kosher salt | 1.0 | 0.9% |
| black pepper | 0.2 | 0.2% |
| TOTAL | 115.0 | 100.0% |

Environmental, Nutritional and Economic Impact Analysis of Blended Burger

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| Saskatchewan Census Division | Lentil production (tonnes) | Lentil acres (harvested) | Yield (tonnes/acre) | Irrigated/ | Bluewater footprint (litres/kg) | Production x Bluewater footprint |
|--|----------------------------|--------------------------|---------------------|------------|---------------------------------|----------------------------------|
| | | | | rain-fed | | |
| 2 | 164200 | 383800 | 0.43 | Rain fed | 0 | 0 |
| 3 | 233400 | 475500 | 0.49 | Rain fed | 0 | 0 |
| 4 | 140800 | 326200 | 0.43 | Rain fed | 0 | 0 |
| 6 | 222500 | 369800 | 0.6 | Rain fed | 0 | 0 |
| 7 | 352485 | 600814 | 0.59 | Rain fed | 0 | 0 |
| 7 | 2515 | 4286 | 0.59 | Irrigated | 398 | 1000790 |
| 8 | 505800 | 813800 | 0.62 | Rain fed | 0 | 0 |
| 11 | 169590 | 246938 | 0.69 | Rain fed | 0 | 0 |
| 11 | 1210 | 1762 | 0.69 | Irrigated | 398 | 481507 |
| 12 | 220300 | 285700 | 0.77 | Rain fed | 0 | 0 |
| 13 | 198900 | 273700 | 0.73 | Rain fed | 0 | 0 |
| | $\Sigma = 2211700$ | | | | | $\Sigma = 1482297$ |
| Weighted average Bluewater footprint for dry Saskatchewan lentils (liters/kg) | | | | | | $1482297 \div 2211700 = 0.67$ |

*Non-irrigated lentil production data taken from crop production statistics of Saskatchewan government:

<https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/market-and-trade-statistics/crops-statistics/crop-district-production>

**Irrigated lentils production data from irrigation survey conducted by Irrigation Crop Diversification Corporation: <https://irrigationsaskatchewan.com/icdc/irrigation-crop-survey/>.