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

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Lentils.™

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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 meat (beef especially) 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). 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. This study compared the nutritional impact, environmental footprints (carbon, water and land use) and cost of regular US beef burgers compared to 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 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 beef/lentil burger compared to the 100% lean ground beef burger.

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. If all beef burgers consumed annually in the US (~10 billion annually) were replaced with blended beef/lentil burgers, this would:

- Reduce greenhouse gas emissions by 11 million tons of CO_2 (equivalents) per year. This is equivalent to the emissions from 2.38 million cars, or all cars from Orange County, California (based on standard registrations of vehicles in California).

- Reduce the demand for water for irrigation by 219 billion gallons, which is the equivalent of 337,400 Olympic-sized swimming pools.

- Reduce agricultural land demand by 12,340 square miles, an area slightly smaller than Maryland.

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.

References

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2. Chaudhary, A. and Krishna, V., 2019. Country-specific sustainable diets using optimization algorithm. *Environmental science & technology*. 53(13), 7694-7703

3. Clune, S.; Crossin, E.; Verghese, K. 2017. Systematic review of greenhouse gas emissions for different fresh food categories. *Journal of Cleaner Production*, *140*, 766-78

Environmental, Nutritional and Economic Impact Analysis of Blended Burger
Pulse Canada
19-Feb-20

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/MSFPlantBasedLCAReport_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) *Agricultural Systems* (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) Agricultural Systems (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 formulation (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

Pulse Canada

19-Feb-20

	Nutritional factors					
Product	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

Pulse Canada

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%**

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%

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

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19-Feb-20

Saskatchewan Census Division	Lentil production (tonnes)	Lentil acres (harvested)	Yield (tonnes/acre)	Irrigated/ rain-fed	Bluewater footprint (litres/kg)	Production x Bluewater footprint
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
	∑ = 2211700					∑ = 1482297
1482297 ÷ 2211700 = **0.67**		Weighted average Bluewater footprint for dry Saskatchewan lentils (liters/kg)				

*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 Divesification Corporation: https://irrigationsaskatchewan.com/icdc/irrigation-crop-survey/).