PETALUMA LIFE CYCLE ASSESSMENT

Last Updated: January 21st, 2022

BAKED DOG FOOD | ROASTED PEANUT BUTTER & SWEET POTATO FLAVOR

SUMMARY

Petaluma, Inc. formulates and distributes dog food products, including a plant-based recipe designed to provide complete and balanced nutrition for adult dogs of all breeds (as defined by the American Association of Feed Control Officers [AAFCO]).

Petaluma commissioned a life cycle assessment from GreenStream Consulting to compare the environmental impacts – chosen here as greenhouse gas emissions, freshwater use, and land use impact – of Petaluma's formula with those from the average dog food purchased in the United States. This study also highlights and informs opportunities for improvements in the environmental performance of Petaluma's products.

The Petaluma diet analyzed here – Roasted Peanut Butter & Sweet Potato Flavor for Adult Dogs (the "diet" or "formula") – provides complete and balanced nutritional value, as defined by AAFCO and regulated by the FDA, and is considered functionally and nutritionally comparable to other commercial canine diets. The selected comparison unit is the "average" canine diet in the United States, which is modeled based on the ingredient composition of the most popular 500+ commercial canine diets weighted by total US sales of each product.

This comparative assessment estimates that the Petaluma diet generates ~83% fewer greenhouse gas emissions, requires ~62% less freshwater, and has ~88% less land use impact than the average commercial diet of U.S. dogs (Table 1). For the average American dog (based on weight and calorie consumption), the annual impact translates to a 1,000 kg reduction in greenhouse gas emissions (CO_2 equivalents), conservation of 100,000 liters of freshwater, and a reduction of almost 6,000 square meters of land use impact.

Table 1. Comparison of total cradle-to-gate impacts of a dog's average annual calorie requirement provided by the Petaluma diet versus the average commercial dog food.

Yearly Impact - Diet of Average Dog (364K kcal)	**Greenhouse Gas Emissions** kg CO2e / year	**Freshwater consumption** Liters / year	**Land use** Square meters / year
Traditional	1,208	161,076	6,561
Ingredients	1,072	131,279	6,555
Transportation	9	0	0
Processing	122	29,743	6
Packaging	5	55	0
Petaluma	200	61,746	755
Ingredients	158	31,942	749
Transportation	9	0	0
Processing	29	29,743	6
Packaging	4	61	0
Petaluma savings	**1,008**	**99,330**	**5,806**
vs. traditional dog food	*-83%*	*-62%*	*-88%*

METHODOLOGY

This assessment considered the cradle-to-gate environmental cost of producing dog food, including the resource consumption required to produce the ingredient inputs, transport ingredients to a manufacturing facility, transform the inputs into the final product, and package the product into the end customer saleable format. This analysis does not consider distribution to the point of sale or disposal of the waste products.

Impact factors for greenhouse gas (GHG) emissions, water consumption, and land use were calculated based on peer-reviewed academic databases and research publications, as well as manufacturer data where available and appropriate (e.g. plant proteins that require significant resources in processing). Each impact category used the most appropriate database available based on the scope, methodology, and comparability of the studies.

The impact factors were normalized based on calories and the impacts were calculated based on the caloric consumption of various dog sizes. Estimated caloric consumption for the average dog was based on the research of Dr. Gregory Okin [12], and for other dog sizes, the estimates from Pet Nutrition Alliance were used.

Ingredients

The environmental impacts of ingredients – including ingredient production and any pre-production processing that occurs before it is used as an input at the transformation phase - were estimated using a bottom-up approach in which the impact factor for each ingredient was calculated and weighted based on its inclusion rate in the formula.

The preferred databases for each impact category are outlined below:

- **Climate**: dataFIELD (University of Michigan Center for Sustainable Systems) [1]
- **Water**:
  - Our World in Data [2]
  - Water Footprint Network [3]
- **Land Use**: Our World in Data [2]

Where data were missing, additional research was conducted to find alternative databases. When comparable LCA studies were not available, assumptions where made based on products with similar agricultural and manufacturing inputs.

The assessments analyzed the top 90% of ingredients by formulation weight. The ingredient composition of the average dog food ("traditional") was based on an analysis commissioned by trade groups representing the pet food industry [7]. The report estimated the national consumption of each pet food ingredient by 1) analyzing the ingredient labels of more than 500 top-selling dog food products and 2) weighting the ingredient composition by product sales across the largest retailers (from Nielson data).

When necessary, this assessment converted the ingredient inclusion in the food "as sold" (i.e., after processing and/or water loss) to the implied inclusion rates of the raw input to facilitate a like-for-like comparison with the calculated impact factors in the database. For example, chicken meal was converted to the equivalent mass of pre-processed chicken (prior to water loss) when weighting the traditional diet inclusion rates.

Additional factors were applied to the GHG and land use impact metrics to account for differences between organic and conventional farming practices based on a meta-analysis of over 742 agricultural systems and 90 food products [4]. The study calculates no significant difference between GHG emissions of organic and conventional farming practices for all agricultural products except fruits, dairy, and eggs. The meta-analysis concludes that organic farming requires 10-90% more land use impact than conventional agriculture, with specific factors applied based on the broader ingredient category (vegetables, grains, pulses, etc.).

Transportation

This analysis considers transportation impact as the final delivery from input production to "retail" buyer, which in this case is the pet food manufacturer. The transportation of inputs as part of ingredient production (e.g. transporting grain feed for livestock) is not included as it is factored into the impact metrics for each ingredient. This analysis utilizes the estimated

GHG emissions of final delivery transport based on an input-output life cycle assessment that considers total "food-miles," mode of transport, and fuel source for 50 food commodities [8].

The absolute GHG emissions attributed to final delivery transportation are similar across food categories and represent a relatively small portion of total greenhouse gas emissions. This analysis assumes a contribution of 25 g CO_2e / 1000 kcal of dog food for both the traditional diet as well as the Petaluma diet given significant geographic overlap in most ingredient suppliers and modes of transportation.

Due to a relatively nascent plant protein supply chain and a lack of qualified local suppliers, some Petaluma ingredients are imported from Europe, including an organic pea protein concentrate and a potato protein isolate. These ingredients were allocated additional transportation-related greenhouse emissions based on country of origin and long-haul sea freight emission estimates.

Processing

This analysis leverages a life cycle assessment from the Center for Earth Systems Management and Engineering (CESME) at Arizona State University that measured the energy consumption and water withdrawals of a large dry dog food manufacturing facility in Arizona [9]. The CESM analysis estimated 1.22 kg of CO_2e per kilogram of dry dog food based on an energy requirement of ~1.7 kWh / kg of food and the fuel mix of the local Arizona power grid at the time. The study's estimate of freshwater withdrawals at the facility – 79 gallons / kg of food produced - was also used here, which includes water required to operate and clean the equipment as well as water added as a food input.

The Petaluma diet is manufactured in a facility that is primarily powered by a solar panel array installed adjacent to the facility in 2020. The amount of electricity generated by the solar panel system varies based on available sunlight, but on average provides ~65% of the facility's annual energy requirement. This analysis attributes the U.S. Department of Energy's median estimate for lifetime emissions associated with solar photovoltaic cells – 0.05 kg CO_2e / kWh - to the portion of energy derived from the local solar panel array [22]. The remaining processing energy is drawn from the Illinois power grid, which was attributed average GHG emissions of 0.39 kg CO_2e / kWh [23].

This analysis assumes the Petaluma diet requires 1.7 kWh / kg of food in processing energy estimated in the CESME study as the equipment required to product this diet (including mixers, conveyor belts, dryers, and packaging automation systems) are similar across pet food manufacturing facilities. However, the CESME study considers extruded dog food, which utilizes different equipment than Petaluma's baked diet. However, other LCA studies examining commercial bakeries provide similar estimates of energy requirements for bread mixing and baking (~1.5 kWh / kg of commercially-baked bread), which utilizes comparable equipment to Petaluma's baked dog food [10].

Packaging

This assessment considers only the packaging materials applied at the factory to create individual saleable units, and not packaging used as part of end customer distribution (e.g. shipper boxes, cartons, or pallets).

The resource impact of the packaging is estimated based on the impact factors for the specific materials and normalized based on the amount of nutritional energy the packaging holds (kg of packaging materials per kcal of food). This assessment used the impact factors for each packaging material assigned by the CleanMetrics CarbonScope database [11].

The Petaluma diet is packaged in a multi-layered bag that is comprised of kraft paper, polyethylene terephthalate (PET), and linear low-density polyethylene (LLDPE), with a packaging mass of ~16 g / kg of food (net weight). The packaging material composition of the average commercial dog diet was estimated using an internal analysis of 10 bags from top-selling products. The bags incorporated rolled aluminum, polyethylene terephthalate (PET), and linear low-density polyethylene (LLDPE) in varying thickness and mass, with an average total packaging mass of 11 g / kg of food (net weight). The relative mass of each packaging material was estimated based on specification sheets provided by packaging suppliers.

RESULTS

The Petaluma diet generates 83% fewer GHG emissions, requires 62% less freshwater, and results in 88% less land use impact than the average commercial dog diet.

The analysis concludes that Petaluma's diet generates 0.55 kg CO_2E / 1000 kcal of GHG emissions compared to the 3.32 CO_2E / 1000 kcal for the average commercial dog diet. The majority of emissions are attributed to the production of the raw inputs, which account for 79% of Petaluma's impact and 89% of the traditional dog diets.

The Petaluma diet requires the consumption of 170 liters blue water / 1000 kcal compared to 443 liters blue water / 1000 kcal for the average commercial dog diet. Production of raw inputs also accounts for the majority of blue water consumption – 52% of the Petaluma footprint and 82% of the traditional diet footprint.

The Petaluma diet results in 2.1 $meters^2$ land use impact / 1000 kcal, whereas the average dog diet is responsible for 18.0 $meters^2$ land use impact / 1000 kcal. The land use impact is almost entirely associated with raw input production, as the impact of transportation, processing, and packaging is negligible.

The significant difference in GHG emissions, blue water consumption, and land use impact is primarily attributable to the ingredient selection, and particularly the use of animal-derived, and particularly ruminant-derived ingredients, in traditional dog diets. Table 2 and Table 3 show the specific impact factors attributed to the most prevalent ingredients in Petaluma and the average dog diet.

Table 2. Traditional dog food ingredient composition and impact factors.

Traditional Dog Food (based on published industry data)	*As sold (post-processing)* % of food (by weight)	*As raw ingredient* % of food (by weight)	Greenhouse Gas kg CO2e / kg food product	Freshwater Use Liters water / kg food product	Land Use Square meters / kg food product	kcal / kg food product
Corn	20.2%	13.5%	0.6	216	3	3,860
Meat and Bone Meal	10.2%	17.8%	12.3	1,145	76	2,170
Chicken	9.6%	9.4%	4.2	660	12	1,430
Soybean Meal	7.0%	4.8%	0.4	149	4	3,270
Corn Gluten Meal	4.8%	3.2%	2.0	2,306	3	3,640
Chicken By-product Meal	4.1%	7.7%	4.2	660	12	1,430
Chicken Meal	3.6%	6.7%	4.2	660	12	1,430
Wheat	3.1%	2.1%	0.3	648	4	3,390
Beef	2.8%	3.1%	33.1	2,083	185	2,470
Beef Fat	2.5%	1.5%	33.1	2,083	185	9,020
Beef and Bone Meal	2.1%	2.5%	33.1	2,083	185	2,470
Pea Flour	1.9%	1.3%	0.7	397	7	3,330
Wheat Flour	1.9%	1.3%	0.4	648	4	4,670
Poultry By-Product Meal	1.9%	3.5%	2.8	660	12	1,430
Animal Fat	1.6%	1.0%	12.3	1,145	76	2,170
Brown Rice	1.4%	1.0%	2.1	2,248	3	3,700
Brewers Rice	1.4%	1.0%	1.5	2,248	3	3,700
Organ Meat	1.3%	0.9%	12.3	1,145	76	2,170
Lamb	1.2%	1.2%	24.0	1,803	370	2,820
Rice	1.1%	0.8%	2.1	2,248	3	3,700
Chicken Broth	1.1%	0.7%	1.2	189	3	360
Meat By-Products	1.0%	1.5%	12.3	1,145	76	2,170
Chicken Fat	0.9%	0.6%	4.2	660	12	9,000
Beet Pulp	0.8%	0.5%	0.2	28	0	430
Salmon	0.7%	0.8%	5.7	3,691	8	1,270
Turkey	0.7%	0.5%	2.6	660	12	1,480
Lamb Meal	0.7%	1.2%	24.0	1,803	370	2,820
Soy Flour	0.6%	0.4%	0.4	149	4	4,340
Weighted Total	90.1%	90.1%	**6.9**	**847**	**42**	**2,346**
		per 1000 kcal	2.9	361.1	18.0	

Table 3. Petaluma ingredient impact factors. *Note: The recipe's formula and inclusion rates are a trade secret and not shared.*

Petaluma – Roasted Peanut Butter & Sweet Potato Flavor	Greenhouse Gas kg CO2e / kg food product	Freshwater Use Liters water / kg food product	Land Use Square meters / kg food product	kcal / kg food product
Organic chickpeas	0.5	224	18.7	3870
Potato protein isolate*	3.6	29	0.9	3350
Organic oats	0.5	181	9.9	2460
Dried brewer's yeast*	3.2	51	2.8	3250
Pea protein isolate*	0.7	403	7.5	3350
Organic peanut butter	1.5	367	18.7	5980
Organic sweet potato	0.3	5	1.5	850
Organic barley	0.2	110	1.4	3540
Organic flax seed	0.4	268	4.6	5340
Sunflower oil	2.7	299	11.2	8840
Peanut oil	4.7	2477	18.8	8840
Organic brown rice syrup	2.3	2250	3.6	3448
Carrots	0.1	28	0.3	410
Weighted Total (top 90%)	**1.1**	**229**	**5.4**	**2,601**
per 1000 kcal	0.43	88	2.1	

*based on data provided by the manufacturer

Table 4. Resource use per 1,000 kcal of dog food

	per 1000 kcal		
	Greenhouse Gas	Freshwater Use	Land Use
Ingredients	kg CO2e	Liters	Square meters
Traditional	2.95	361.1	18.0
Petaluma (PBSP)	0.43	87.9	2.1
Transportation			
Traditional	0.03	0.0	0.0
Petaluma	0.03	0.0	0.0
Processing			
Traditional	0.33	81.8	0.0
Petaluma	0.08	81.8	0.0
Packaging			
Traditional	0.01	0.1	0.0
Petaluma	0.01	0.2	0.0
TOTAL			
Traditional	3.32	443.1	18.0
Petaluma	0.55	169.8	2.1
Petaluma vs. Traditional	*-83%*	*-62%*	*-88%*

KEY ASSUMPTIONS

- **Treatment of by-product**: For the purposes of consumption impact estimates, the dog food ingredients were not considered waste by-products and allocated discounted impact factors. Most raw ingredients used in pet food ingredients could have be consumed by humans, including those ultimately classified as "feed grade" because manufacturers choose to route them to processing facilities that fall outside of government regulations for human consumption. Offal and other animal co-products are consumed by humans around the world and have significant economic and nutritional value. Many leading researchers and prominent LCA databases (dataFIELD, Okin 2018) allocate the same impact factors for both the primary (e.g. ground beef) and secondary co-products (e.g. offal) and further supports this approach.

  While some ingredients used in pet food cannot be legally sold for human consumption, industry data suggests common pet food ingredients like rendered animal products and meat meals do not use significant amounts of truly feed-grade inputs. The leading rendering industry group estimates that less than 5% of rendered animal products come from livestock classified as *dead, dying, downed, or diseased*, which cannot be sold for human consumption [6].

- **Green/blue/grey water consumption**: There are three types of water impacts and this study focuses on blue water impacts, which is "blue," or freshwater consumption. Freshwater is the most relevant environmental impact metric as it reflects "discretionary" water consumption that could be feasibly be allocated to different uses. Blue water use is equivalent to the concept of "freshwater withdrawals" used in many LCAs. Geography-specific water scarcity factors were not considered in this analysis due to the national (and often international) supply chain of pet food that complicates the ability to assign region-specific scarcity estimates.

- **Impacts of organic versus conventional production**: To account for the impacts that organic agricultural practices may have on GHG emissions and land use, this analysis applies factors based on a 164-study meta-analysis of organic farming impact factors (Clark and Tillman, 2017 [4]). The implications of organic practices on water withdrawals were not accounted for, as reliable research on the subject has yet to be conducted, as supported by Seufert and Ramankutty, 2017 [5]. We selected the factors from a broad, global meta-analysis (rather than geographic- or ingredient-specific studies) to reflect the global supply chain that is required for large-scale pet food production.

- **Traditional dog food ingredient composition and inclusion rates**: We rely on data provided in a report commissioned by the Institute for Feed Education & Research (IFEEDER), Pet Food Institute, and North American Renderers Association, the leading pet industry trade groups representing manufacturers, distributors, and suppliers [7]. The analysis "reverse engineers" the ingredient composition of 500+ dog food products based on the displayed nutritional labels and estimates inclusion factors based on label order. The analysis weighs total ingredient composition for each formula by US sales data to estimate a national total. The sales data are derived from 52 weeks of data at major pet food retailers from July 2018 – July 2019.

- **Data variability**: It should be noted that there was considerable variability between the impact factors across peer-reviewed sources. Although this study always attempted to use the most comparable data set, the number of variables and differences in scope amongst the studies available are likely to produce a considerable margin of error. However, the tool will still be effective for making actionable decisions regarding ingredient choices and their relative environmental impacts.

IMPACT COMPARISONS

To provide additional context and benchmarks for the scope of impact of Petaluma and traditional dog food, this analysis seeks to frame the reduction of GHG emissions, freshwater consumption, and land use impact in terms of more common actions that consumers associate with environmental conservation. Almost the entirely of environmental impact and resource consumption involved in the production and processing of pet food occurs out of sight of the end consumer, whereas decisions like choosing more efficient transportation methods for a daily commute or limiting landscape irrigation have more obvious conservation effects. This study pulled from existing assessments of common actions and decisions that environmental and governmental organizations often recommend for households to reduce their resource use and GHG footprint (Table 5).

This study calculates the annual impact of feeding dogs of different sizes the Petaluma diet compared to the average commercial dog diet and frames them in terms of the most appropriate equivalent action referenced in Table 5.

Table 5. Environmental impact factors for common household actions

		Metric	Notes	Source
Greenhouse Gas Emissions				
Producing electricity (USA)	**1.56**	lb C02e / kWh	United States average	Environmental Protection Agency [13]
Powering a refrigerator	**1,013**	lb C02e / year	Assumes 650 kWh/yr electricity requirement	EnergyStar [14]
Driving in private car	**0.89**	lb C02e / mile	Assumes 22.3 miles per gallon	Environmental Protection Agency [13]
Commuting to work in a private car	**6,944**	lb C02e / year	Assumes 15 mile commute per business day	US Department of Transportation [15]
Commuting to work via public transit	**3,255**	lb C02e / year	Assumes average mix of US transit (light rail, bus, etc.)	US Department of Transportation [16]
Traveling on a mid-range passenger flight	**0.46**	lb C02e / passenger mile	Assumes 1500 - 4000 km flight	U.K. DEFRA [17]
Traveling on roundtrip flight from Los Angeles to Denver	**1,033**	lb C02e	Approximately 1,200 miles each way	U.K. DEFRA [17]
Freshwater Consumption				
Shower flow	**2.1**	gallons / minute		Water Research Foundation [18]
Shower (annual)	**6,278**	gallons / person / year	Assumes 8 min / person / day	Water Research Foundation [18]
Laundry machine (annual)	**3,041**	gallons / person / year	Calculated based on household consumption & avg. size	Water Research Foundation [18]
Producing new pair of jeans	**1,294**	gallons / pair of jeans	Global average assuming 1 kg. of material	UNESCO Institute for Water Education [19]
Producing new t-shirt	**325**	gallons / t-shirt	Global average assuming 250g of material	UNESCO Institute for Water Education [19]
Grass lawn water requirement	**0.7**	gallons / sqft lawn / yr	Assumes lawn 1" of water per week	Sierra Club [20]
Dry season irrigation requirement (annual)	**14.3**	gallons / sqft lawn / yr	Assumes 21 weeks of irrigation / year	Sierra Club [20]
Land Use Impact				
Tennis Court	**0.06**	acre	United States Tennis Association regulations	USTA
NFL football field	**1.32**	acre	National Football League regulations	NFL
FIFA soccer field	**1.78**	acre	FIFA regulations (~2.5% variance allowed)	FIFA
MLB baseball field	**2.49**	acre	Average fair territory in MLB baseball field	Business Insider [21]

Table 6. Comparison of Petaluma production savings to common household actions based on annual caloric requirement of dogs of various sizes.

Dog Size	lb	20	45	70	100
Annual Calorie Requirement	kcal	187,610	343,465	478,880	625,610
Reduction in GHG emissions (Petaluma vs average dog food)	lb C02e / yr	**1,145**	**2,096**	**2,922**	**3,817**
Equivalent impact		1.1x years of unplugging a refrigerator	Driving ~2,300 fewer miles (~79 days of commuting)	Forgoing 2.7x roundtrip flights LA to Denver	270 days of commuting via public transit vs. driving
Reduction in freshwater usage (Petaluma vs. average dog food)	gallons	**13,525**	**24,761**	**34,524**	**45,102**
Equivalent impact		2.1x people not showering for a year	8.1x people not using a laundry machine	Forgoing production of 21 new outfits (jeans & shirt)	Stop irrigating 3,150 sqft of lawn for one year
Reduction in land use impact (Petaluma vs. average dog food)	acres	**0.74**	**1.36**	**1.89**	**2.47**
Equivalent impact		11.1x tennis courts	1.0x NFL football field	1.1x FIFA soccer field	1.0x MLB baseball field

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