

Carthage College

Reducing our Diet's Carbon Footprint:

Dairy vs Almond Milk

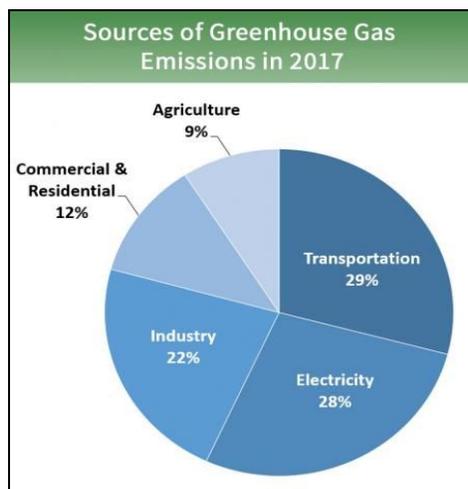
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Introduction:

One of the growing concerns in our society today is the health of our planet and reducing the amount of pollution that we create. One of the biggest subjects of pollution in our society is from agriculture and more precisely the livestock side of agriculture. The EPA (Environmental Protection Agency) has stated that Agriculture is



responsible for nine percent of greenhouse gas emissions in 2017, **see chart 1**, and looking deeper into the percentages the livestock in agriculture are only responsible for about four percent of greenhouse gas emissions. Another study to look at is on the University of Michigan's website that talks about the pollution created by the average American

diet. According to The University of Michigan the average consumption of food per household in the U.S. produces about 8.1 metric tons of CO_{2e} a year. One way that politicians and environmentalists have decided to reduce the amount of CO_{2e} produced by the average Americans diet is by reducing the consumption of high pollution producing products. One of the products in the average American diet that has been viewed as high pollution producing is meat such as beef, chicken, pork, and so on. Another product viewed as high pollution producing in the average American diet is milk from cows. Since Carthage College is in Kenosha Wisconsin, and Wisconsin is known

as the dairy state, this study will be looking more deeply into the pollution produced by the dairy industry and determine if there really is a huge environmental problem with dairy milk. This study will also be comparing dairy milk to almond milk and seeing if this popular plant based milk is a safer alternative to cow's milk environmentally. The reason this study will be looking at almond milk along with cow's milk is because about 80% of the world's almond supply comes from California, therefore these are two milk products that are grown and produced in the United States. Along with all of the environmental topics that were mentioned thus far this study will also talk about the economic side of these two milks. Economics play a prominent role in getting bills passed to clean up our environment. This study will be looking at the amount of money that almond and dairy milk bring to the U.S. economy and if missing one of these milks would affect our economy or not. This study will also be looking at the economic side of the two milks by looking at the amount of money spent on water to produce the milk, how much money is usually spent on preparing the land to produce the milk, and how much money is spent on the electricity to produce the two milks. When looking at the electricity side of the two milks economically you have to bring into consideration the recyclable use of the waste from the two products. If these two products are able to recycle themselves and be converted into energy to produce electricity then they might be able to sell that excess energy to the electric company along with reducing the need for dirty traditional power plants. An example of a milk product turning its waste into a profit is cow manure. A

farmer from Vermont used the manure from his dairy cattle and put it in a digester machine to create energy and sold it back to the electric company for a profit (Cow Power). A digester machine is a new technology that takes cow manure and food waste to produce electrical energy. This machine will also produce fertilizer and livestock bedding along with electrical energy. This machine takes what is usually just a fertilizer and polluter and turns it into multiple different uses and a source of green energy. The U.S. government is starting to give out grants to farmers who are interested in installing these digester machines on their farms to reduce methane pollution and produce green energy.

The first part of this experiment is to look at the pollution created by both of these two milks. One way that this study will look at the pollution created by these two milks is by analysing a LCA (Life-cycle Assessment) of both dairy and almond milk. By looking at the LCA of these two milks this study will show how much pollution is created by both milks. One set of information that this study will analyze is peer reviewed papers that talk about the pollution created by dairy farms along with almond farms. For example, in a study done by the University of California San Francisco they note that twenty three thousand acres of wetlands in California were converted into almond farm fields. This paper explains how California is destroying its wetlands to keep up with its demands for almonds. Another example that this study will look at is a study done by the United Nations Animal Production and Health Division. This study looks at the greenhouse gas

emissions from the dairy sector and according to their study they stated that milk accounts for 328 million metric tons of CO₂ that is released into the atmosphere a year. Another way that this study will input into the LCA is by the Carnegie Mellon University LCA tool that shows some of the pollutants that go into making these two milks.

The second part of this experiment will be looking at the ways that these two milk products can be recycled and reused to decrease their carbon footprint. This study will also be looking at the potential that these two milk have at making a difference in decreasing the greenhouse gas created by traditional electricity. An example for almonds decreasing greenhouse gas, created by traditional electricity, is that almond farmers can use the organic waste of the almond to produce electricity. An example that this study can look at for the potential of lessening the pollution created by dairy farms is the new technology created that takes the manure produced by cows and turns it into a greener energy source, as mentioned previously in the paper.

An LCA (Life-Cycle Assessment) is a great way to look at the environmental impact of a product on our environment. The reason that an LCA is a great way to look at the impact of pollution is because the LCA lays out the information very simply. For the LCA that will be done in this experiment this study will be looking at the land use, water use, and the energy use of both milks and see the total impact that they have on their environments. When this study looks at land use of the milks the study will be looking at the amount of land that is required to create the product and the effects that

this product has on the land. This study will also be looking at the water use of these two products. Water is an important resource on this earth and droughts are becoming an even bigger problem on our planet today. The LCA will look at how much water is required to produce the two products of milk. The last thing that this study will be looking at in the LCA is the energy use required to produce these two products. This study will be looking at how much electrical energy that is required to run the two operations to produce the milk products of dairy cattle and almonds.

Literature Review

This study will be looking at an overabundance of different scientific articles and studies that have been done on the pollution created by these two products and what recyclable quantities that these two products have. This study will be looking at the articles and studies done that talk about the pollution created by these two products, and this study will also be looking at the articles and studies that talk about the recyclable quantities of these two products.

One of the first pieces of information that this study will look at is from a documentary that looked at a farmer from Vermont who converted his traditional farm into an energy creating farm. The St. Pierres family owns a farm in Vermont. The St. Pierres family spent about \$73,000 dollars on electricity to power their farm a year, and after they installed this new technology called a digester they were now making close to \$365,000 in profit in selling excess energy to the electric company (“Cow Power”). The

digester is a new technology that converts the manure waste, that would be pollution, to a greener energy source that will cut down on pollution.

In a study done by Giacomo Pirlo called “Cradle-To-Farm Gate Analysis of Milk Carbon Footprint: A Descriptive Review.” Giacomo talks about how the change in a cow’s diet can reduce the amount of pollution that a cow will produce in farts and manure, and how that same change in diet can actually increase the amount of milk production from a single cow (Giacomo, Pirlo). The pollution that this diet decreases is the methane that is produced by the manure from the cows. Giacomo talks about how a simple change in diet can decrease the negatives and increase the positives.

In another study in the EFSA journal vol. 7, no. 3 titled “Food Safety Aspects of Dairy Cow Housing and Husbandry Systems” looks at the diet of cows again and how this can decrease the pollution created by cow manure and farts. This study also looks at how you treat the cow and how treating the cow can decrease the amount of pollution that a cow will produce throughout its life.

In another study done by Di Liang of UW-Madison they conclude that the more milk you can produce from a cow and the more efficient a cow can be will decrease the amount of pollution from the dairy industry. Di Liang explains that if we can get cows to produce more milk and produce more milk more efficiently then we will not need to replace the cows as much. If we do not need to replace the cows as much as we

currently do then we do not need to put as much energy and water into maturing a new cow to take its place. So along with a greener diet Di Liang looks at ways to increase the life usage of each dairy cow.

Jelena Ariva does a study on how Estonia plans to increase the milk production in the global market by 30% while decreasing the amount of greenhouse gas emissions that it produces from the dairy industries. This study talks about how they are decreasing the amount of pollution that their cows are producing. They note that they are increasing the amount of cows in their dairy sector and that the pollution is also increasing, but the amount that it is increasing by is not as high as the usual percentage that we would expect.

Another study we will be looking at that focuses on almonds is by David A. Goldhamer. The study by David A. Goldhamer looks at how much you can cut back on water before it starts affecting the yield of the almond on the almond farms. This is an important study to look at because 80% of the world's almonds are grown in California and California is usually in drought conditions. This study focuses on finding how much water that can be saved without destroying the almond yield.

The next study that will be looked at is done by Kirk Kardashian and this study looks at the shift of family farms to corporate farms. Kirk Kardashian talks about the death of the family dairy farms across America and the emergencies of the corporate dairy farms. This is bad for the family farms and the average Americans. This affects

the family farmers because the corporate farms can afford to produce the milk with the plummeting dairy prices, and the American people suffer because the corporate farms are dirtier and pollutes the atmosphere more than the family dairy farms.

In a study done by Gutiérrez-Gordillo they looked at three different ways to irrigate an almond orchard, and what would be the most effective way of irrigating the orchard in drought-like conditions. This study found a way to irrigate crops with lower amounts of water without sacrificing the yield of the almond yield. This study is important to the almond farmers because most almonds are grown in areas of high drought problems so the less water that they needed to produce almonds the better.

A study in the Journal of Industrial Ecology talks about Life-Cycle Assessment of an almond. The Life-Cycle Assessment looked at the greenhouse gas emissions that the almond orchards produced, and also looked at the energy use of the almond farms and see how much energy went into producing the almonds.

These are just a few of the pieces of literature that this study will be looking at in this paper to determine the effect of pollution on our atmosphere, and the effect that these milks have on our economy and if they are crucial to our economy or they can be replaced.

Methods:

To be able to conduct this experiment this study has to do a method called data mining. First what has to happen is the study has to consider the question that is at hand and go about proficient to answer the question. For this experiment this study will be looking at almond milk and dairy milk and seeing which of these two milks are more economically and environmentally better for our world. Now that this study has a direction toward the topic of this paper this study must now look at the details that go into solving this question. The more in depth details that this study is going to be looking at in this paper is water use, land use, and energy use. This study will be looking more deeply into each of these details and analyzing more in depth on how these features affect our world environmentally and economically.

This study will be looking at the negative features and positive features of these two milks environmentally and economically in water use by seeing how much water that these milks need to water the animal and the plant to be able to produce the milk and also how much of the milk is used in the milk itself.

This study will also be looking at the negative and positive features of these two milks environmentally and economically in land use. When this study looks for the features of land use it will also look at how much land is required to produce the milk, and this will also be looking at how these two milks affect the land that they occupy.

Some of the questions that this study will be looking at answering are 'Does it take away a plethora of nutrients from the ground?', 'Does it affect the physical property of the land?', and 'How much land does it take to produce these two milks?'

The last of these details that this study will be looking at is the energy use of these two milks. This study will have to answer the question of how much electrical energy does it take to produce these two milks and do these two milks have any properties that allow it to be recycled for an energy use to replace the electricity that it uses. This study will also be looking at ways that the waste of these two products can be recycled for food use, bedding use, fertilizer use, and electrical use to lessen the pollution caused to grow those products separately.

One way that this study will be getting the data to look at the pollution caused by these two milks on the water use, land use, and energy use is by looking at Carnegie Mellon University LCA calculator. This tool will show up raw information about these two products and will give us the information to input into the Life-Cycle Assessment that this study is building.

After this study finds all of the data for the pollution of the two milks and the recyclable qualities of the two milks for the land use, water use, and energy use this study will then start comparing the two milks and seeing what milk is better in each area. This paper will look and see what milk requires the least amount of water to produce the milk product, and the paper will look and see which milk product requires

the least amount of land use to produce the milk, and finally this paper will compare the two milks on how much energy is required to produce these two milk products. The way that study will compare these two milk products for water use, land use, and energy use is by using an LCA (Life-Cycle Assessment). This study will use the Life-Cycle Assessment to compare the two milks and look more into depth into the carbon footprint. All of the questions we were asking previously will be answered here in the Life-Cycle Assessment. The Life-Cycle Assessment will be used to decipher the environmental impacts, but the economic impacts will be accessed by comparing the amount of profit that each milk product has and if the milk products financial progression is going into a positive direction or if the financial situation of the milk is going in a downward slope economically. Then once the Life-Cycle Assessment is done and the economic assessment is over this study will look at the results of the experiment and determine which milk is overall better for our world economically and environmentally.

Results:

LCA (Life-Cycle Assessment)

LCA for dairy milk: Raw Material/ Processing				
Input/ Source	Constituent	Description	Quantity	Output
Water	Water needed to produce milk	Farmers always have water for cows to drink in troughs.	30-50 pounds of water a day on average for dairy cows.	Water loss
Food Source	To feed dairy cattle	Fresh Wheat, Corn, Rice, and	456.4 CO pounds/year 2164.9 NH3 pounds/year	Land use and harvesting

		other Grains.	425.5 NO pounds/year 4166.7 Particulate matter pounds/year	pollution of crops.
Other Food Source	Other food source for dairy cattle	Grass field	145.5 CO pounds/year 1025.1 NH3 pounds/year 154.3 NO pounds/year 15.4 Particulate matter pounds/year	Land eaten from and walked on
Electricity	Producing milk	Electric Milkers for Cow udders	123.5 CO pounds/year 2.2 NH3 pounds/year 246.9 NO pounds/year 11 Particulate matter pounds/year	Typical electric plant pollution to take milk from udders
Pasteurization	Makes milk cleaner	Farmers pasteurize milk to kill bad bacteria	600 MJ of thermal and 200 MJ of electric energy	Pollutes the air with using power from a powerplant to pasteurize milk

LCA for dairy milk: Finished product/Transportation				
Input/Source	Constituent	Description	Quantity	Output
Transportation	To transport milk from farm to store	Semi trucks used to transport milk.	1241.2 CO pounds/year 4.4 NH3 pounds/year 672.4 NO pounds/year 13.2 Particulate matter pounds/year	Vehicle pollution
Packaging	Contain the milk	Used to hold the milk	Typical gallon container and etc	Plastic waste after use of milk and contributing to land waste.

Waste Management and Remediation	Waste from dairy cattle from eating	The waste from the cattle after eating all the grain and grass	61.7 CO pounds/year 6.6 NO pounds/year 8.8 Particulate matter pounds/year 6.6 Volatile Organic compound pounds/year	Waste pollution from cattle.
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LCA for Almond milk: Raw Material				
Input/Source	Constituent	Description	Quantity	Output
Fertilizer	To add nutrients to soil	Nutrients added to soil	83.7 CO pounds/year 59.5 NH3 pounds/year 74.9 NO pounds/year 2.2 Particulate matter pounds/year	Fertilizer production pollution to be applied to trees
Water	Survival of tree	An Almond tree needs water to grow	15 gallons of water to produce 16 almonds	Water depletion in an already water low area.
Pesticides	Protection	Protects plants from bugs	Vary by farm	The chemicals have chance of runoff

LCA for Almond milk: Processing Material				
Input/Source	Constituent	Description	Quantity	Output
Pick up machine	Harvest almonds	A Machine used to gather all the almonds	Vary by farm	Vehicle pollution

Almond shell cracking machine	Deshell almond	Deshells almond so that almond can be crushed down to milk.	Vary by farm	Machines use power from a power plant to power machine
Water	To add to crushed up almonds	You need to add water to crushed almonds to make almond milk.	Vary by milk company	More water is used to create milk.

LCA for ALmond milk: Finished product				
Input/Source	Constituent	Description	Quantity	Output
Transportation	To transport milk	Semi trucks used to transport milk.	286.6 CO pounds/year 163.1 NO pounds/year 2.2 Particulate matter (10 micron diameter) pounds/year 6.6 Particulate matter (2.5 micron diameter) pounds/year	Vehicle pollution
Packaging	Contain the milk	Used to hold the milk	Typical gallon container and etc	Plastic waste after use of milk and contributing to land waste.
Water management and Remediation	Waste	Agricultural waste	24.2 CO pounds/year 2.2 NO pounds/year 4.4 Particulate matter (2.5) pounds/year	Pollution from agricultural waste

The Life Cycle Assessment charts show the pollution that is created by both of the milks in each stage of the milking process. These charts show the pollution created from the first process of creating milk to dealing with waste and transportation of the milk. These charts do not show the recyclable qualities of the milks but only the pollution. The

numbers under the quantity section the LCA that have pounds/year are showing the amount of pollution released. This study will look at the recyclable qualities of the milks in the discussion portion of the paper. The dairy and almond milk had similar pollution from transportation. The pollution of the waste of the two milks is very similar too, as seen in the Life Cycle Assessment charts. Some of the items in the LCA can not be properly recorded because the pollution from those qualities would vary from farm to farm depending on how much the farmers use.

Discussion:

The charts that have been provided show that almond milk is not so much better environmentally than dairy milk and is not a better product economically compared to dairy milk. In an article by CNBC, seen in **table 1**, they report that the cow’s milk

industry is worth about \$12 billion dollars while all the plant

Table 1

Milk market share

U.S. sales of cow's milk vs. nondairy alternatives, 52 weeks ending Oct. 26, 2019



SOURCE: Nielsen. Data includes grocery stores, drug stores, mass merchandisers, convenience stores, select dollar stores, select warehouse clubs, and military commissaries.



based milks combined are only worth \$1.8 billion dollars.

Restricting dairy milk to promote a “greener” source

of milk in almond milk would

be a very bad economic

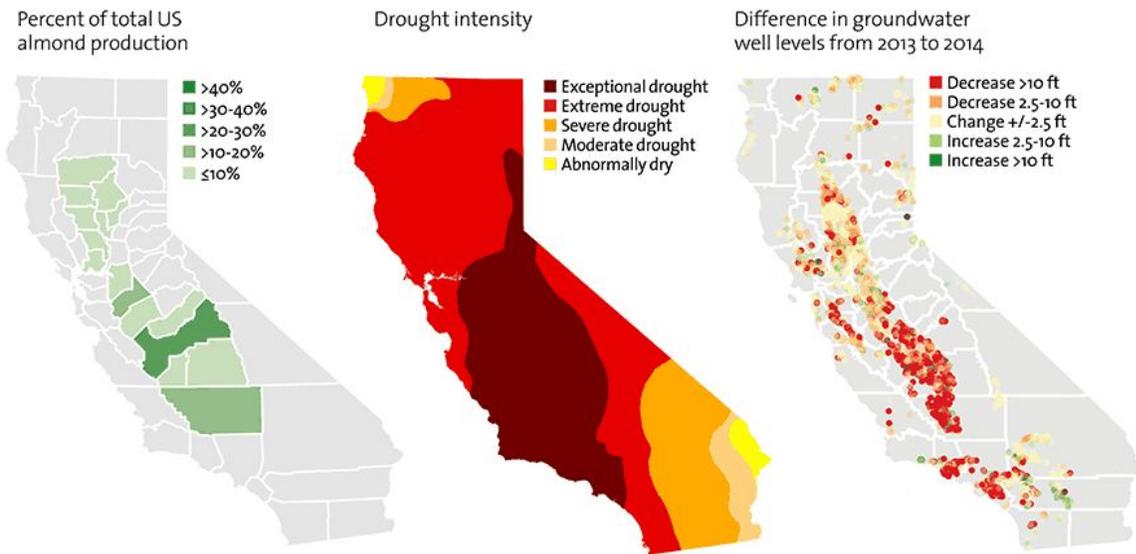
move and the environmental difference between these two milks are not much different.

Dairy milk also gets a negative feedback because of the water use of cows, but the

amount of water needed to grow almonds are killing the places where they can only be grown at (as seen in **chart 2**). The counties in California that have the almond farms are the counties that are experiencing the worst drought conditions and have the highest difference in groundwater well levels. Almond milk itself

Chart 2

California's Almond Counties Are Its Driest—and Most Overpumped



Note: The drought map represents the intensity of the drought as of January 6, 2015. The groundwater map shows data currently available from the California Department of Water Resources. Not all wells in California are part of the database. Sources: US Drought Monitor (drought map); California Department of Water Resources (groundwater levels); California County Agricultural Commissioners (crop maps).

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does not require the same amount of water as cows, but it affects their environment more. Now that the facts have been seen about the effects of almonds on the water supply, this paper will now look at how dairy cows affect the water supply. As seen in **Chart 3** dairy cows do drink a lot of water themselves and are not innocent in its effect on the water supply. The only difference between these two milks in

Chart 3

water use is that dairy milk can be produced in non drought areas

AVERAGE WATER INTAKE BY DAIRY COWS

		Minimum Temperature, F°		
		40	60	80
Milk Yield, lb/d	DMI, lb	Water Intake, gal/day		
40	36	17	20	24
75	48	23	27	30
100	56	28	31	35



while almonds are stuck in drought stricken areas throughout the world. As the Life Cycle Assessment shows from the LCA section above almond milk is not that big of a difference environmentally than dairy milk because almond orchards need fertilizers and pesticides to have the best results.

Another talking point about the negative impact of dairy cows is the manure produced and the pollution that is caused from dairy cattle, but there is new technology

that is lessening the pollution effects from dairy cow manure. According to a study by the Innovation Center for U.S. Dairy and the Cleveland Browns show that a digester machine takes manure and food waste to create green energy along with fertilizer and animal bedding. According to this chart by the Cleveland Browns and the Innovation Center for U.S. Dairy this new machine eases 41,500 tons of greenhouse gasses from cow manure. With this machine the negative effect of pollution caused by cow manure is greatly decreased and turned into a positive by creating green energy. With

Conclusion:

With all of the statistics shown in this paper the results show that almond milk is not a great substitute for dairy milk; However, the almond trees themselves do not produce as much pollution as dairy cows, but the almond trees have a plethora of more strict details to grow healthy and plentiful. The Life Cycle Assessment charts show that the pollution between the two milks are not far off from each other, but the recyclable qualities of dairy milk are showing that it can decrease its carbon footprint by quite a bit according to the Innovation Center of U.S. Dairy. Our planet does have a plethora of problems with pollution from our source of food to the appliances in our homes and the governments of the world need to continue or start to find ways to reduce the carbon footprint produced by its factories and farms.

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