Department of Biosystems and Agricultural Engineering
MICHIGAN STATE UNIVERSITY

BE 230 - Spring 2022
Engr. Analysis of Biological Systems
Dr. Safferman

Environmental Impact of Imitation and Animal Meat Processes
Rachael Lewallen, Andrew Kearney, Yangcheng Gao, Emily Buijink

Introduction

Imitation meat is a plant-based alternative to animal-based meats. They are also commonly advertised as more environmentally friendly. Although, this is true in some cases not all imitation meats are created equal when it comes to reducing environmental impacts. Some sources like soybeans, tofu, etc. are more damaging to the environment than others and more difficult to make. Figure 1 shows the overall production process for plant-based substitutes.
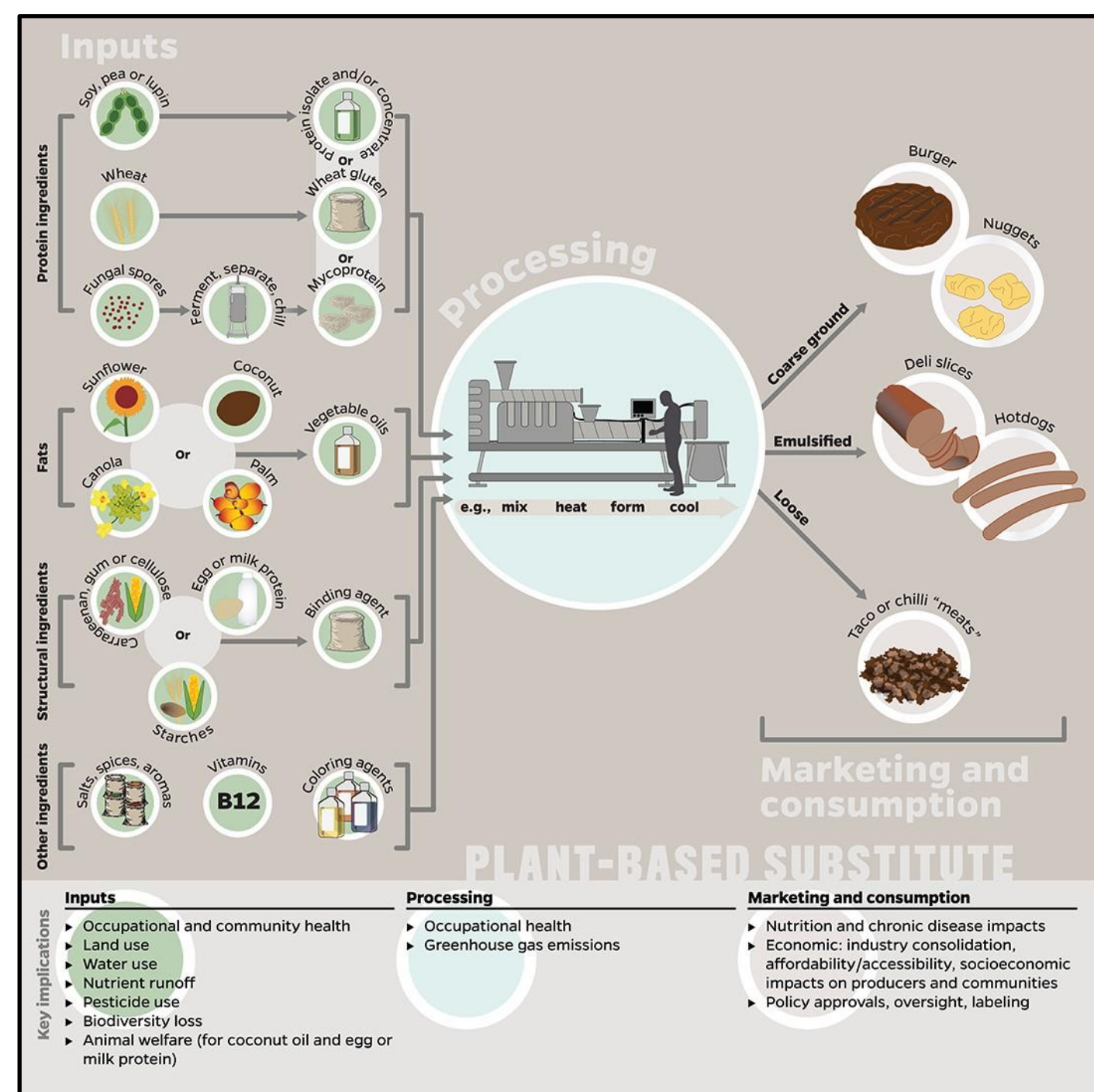

Figure 1: Overall production process of plant-based substitutes

Sensitive Unit

The most critical factor when analyzing the production of both animal-based meat and plant-based meat is the base product used. The process and environmental impact will very greatly with the base product due to factors such as land use, water use, and carbon emissions.

Figure 2: Imitation meat (soybean) burger

Figure 3: Animal meat (beef) burger

Soybean-based imitation meat and beef are promising candidates as examples for imitation and livestock-based processes' life cycle analysis due to their popularity within their respective consumer markets.

Environmental Impact

Livestock production, specifically beef, impacts the environment by increasing gas emissions, land use, waste management, loss of biodiversity and water usage. Animals use 30% of terrestrial land area for grazing, 1/3 of the global cropland is used to produce animal feed and 32% of freshwater is used directly for the livelihood of livestock (1).

A cow eats thousands of pounds of grass, corn, grains, and soybeans in its lifetime. Water and additional land are needed to provide cows with their diet (2). Figure 2 shows the gallons of water required to make one pound of food and as you can see beef is one of the foods that takes the most water to produce using about 1,847 gallons per pound. The water use of soy is 14 times lower than beef.
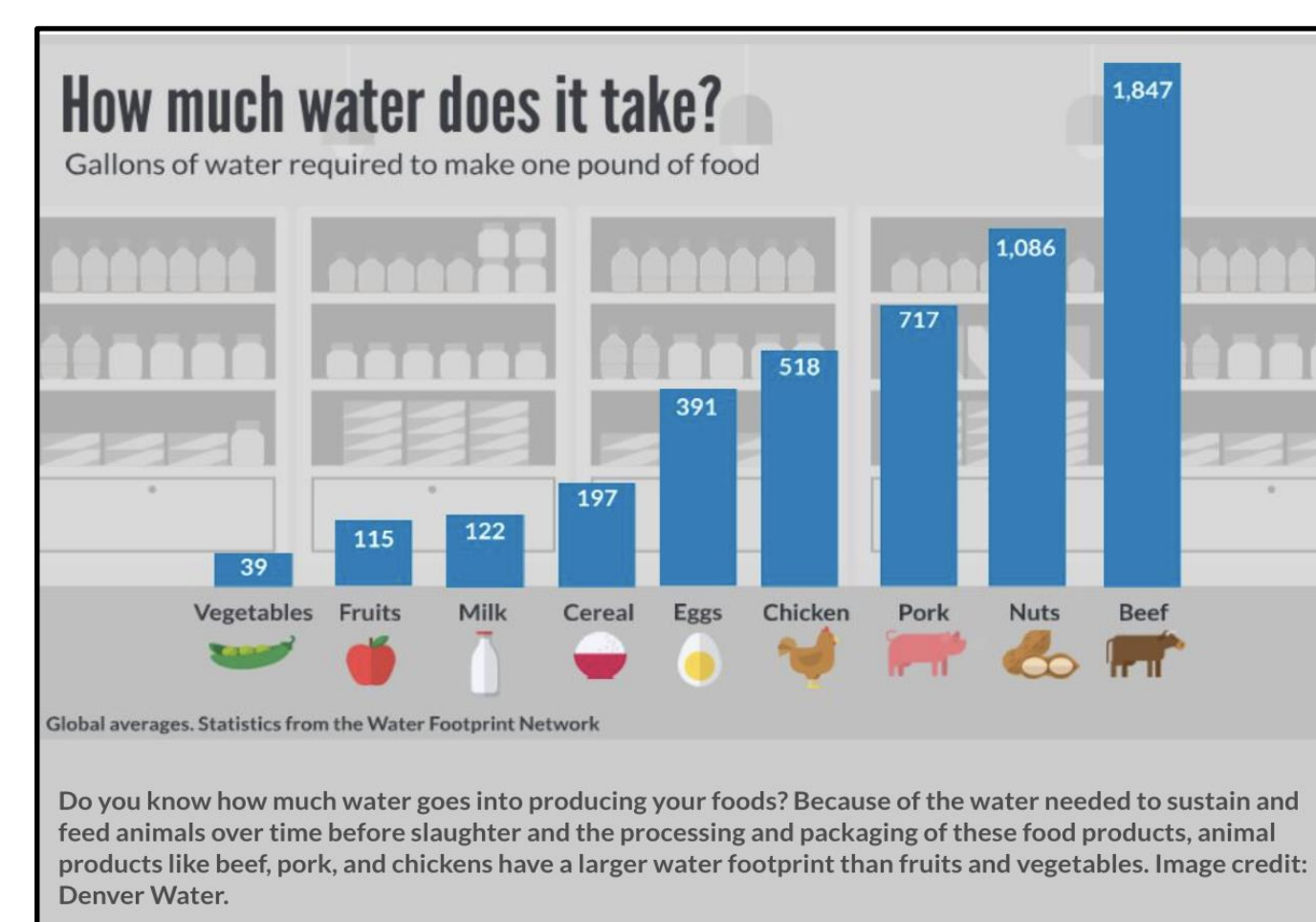

Figure 3: Gallon of water used for production of different food products

Imitation meat is made from ingredients including vegetable proteins, wheat gluten, and soybeans. Overall environmental impact of soy is 32.5 times lower than beef (4). This can be broken down into individual categories. When comparing land use of soy and beef, soy is 58.9 times lower. This can be attributed to the fact that cattle need land to live on but also the feed that is grown for cattle to eat would be considered when calculating how much land is used for cattle.

Greenhouse gas emissions of soybeans are 24.5 times lower than beef (4). These emissions stem primarily from growing practices, greenhouse gases are released from the soil in soybean crops. This value would remain within the total for beef greenhouse gas emissions along with additional emissions because cattle consume soybeans as feedstock as seen in Figure 4.
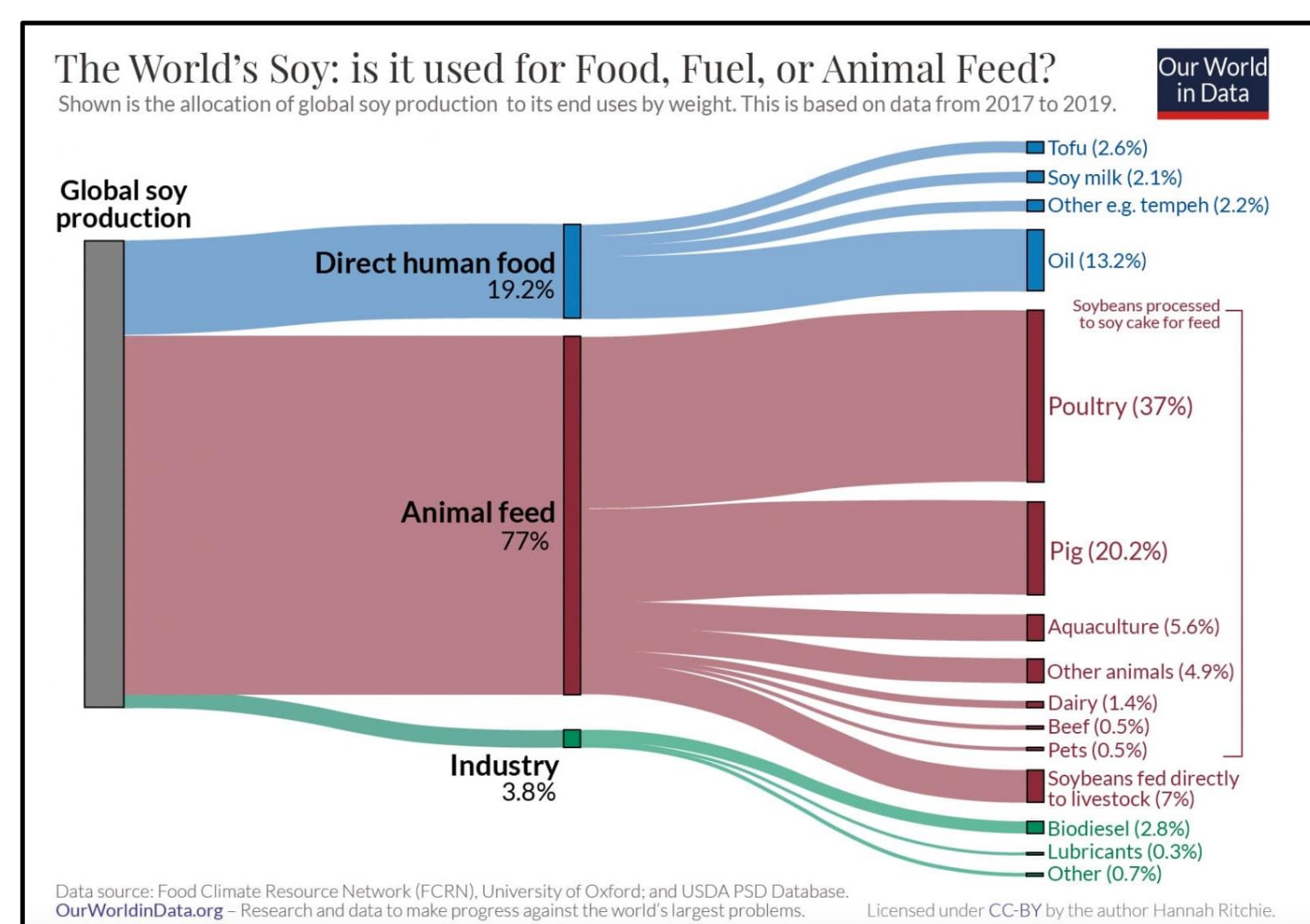

Figure 4: Different uses of soy production

Soybeans are a primary component in the Impossible Burger. As you can see in Figure 3 for greenhouse-gas emissions, beef has the highest greenhouse-gas emissions at 99.5 kg of CO_2 equivalent per kg. while the impossible burger has the lowest at 3.5 kg of CO_2 equivalent per kg.

The greenhouse-gas emissions associated with beef primarily stem from raising cattle. Methane and ammonia are the most prominent greenhouse gases that contribute to global warming, both of which are released from cattle due to enteric fermentation during digestion. This means that the process by which cattle break down their food after consumption produces these harmful gases (3).

Figure 5: Environmental impacts of various types of meat including plant-based meats

Process Description

Imitation Meat Process (Soybean) Breakdown:

1. Plant materials (soybeans) are grown
2. Proteins extracted from plant materials
3. Structuring plant material proteins using extrusion
4. Addition of color, flavor, and aroma
5. Treated for contamination
6. Transported and sold to consumer

Livestock (Beef) Processes Breakdown:

1. Cattle are raised by farmers
2. Cattle are slaughtered and cut into halves or quarters once the slaughter process is complete including cleaning
3. The beef is cut into desired cuts such as steaks, roasts, and other cuts
4. The trimmings from those cuts are sent to meat plants to be ground and shaped into hamburgers (ground beef cannot have more than 30% fat)
5. Hamburgers are not allowed to have any additives other than spices but if it's marketed as a beef patty as opposed to a hamburger, it may contain additional ingredients such as binders & extenders
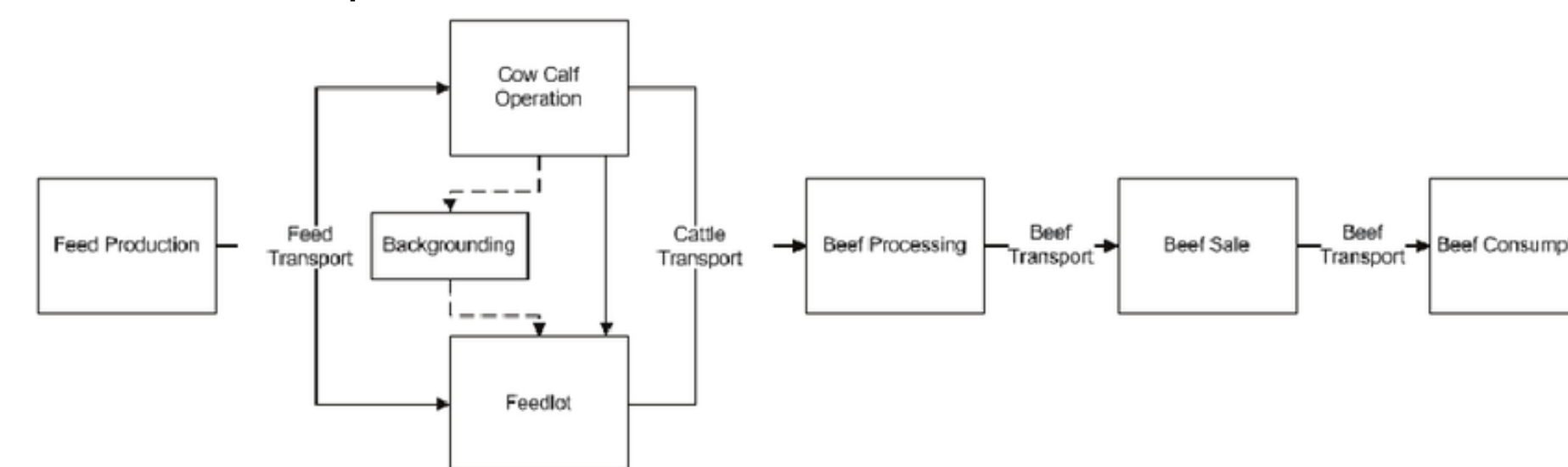6. Packaged for transportation
7. Transported and sold to consumers

Figure 6: Overall production process for animal meat (beef)

Research

Soybean based meat products are much better for the environment when compared to beef-based products. Unfortunately, there is a stigma surrounding imitation meat products that keeps consumers from buying more soy-based products. To figure out the reason behind consumer preference the following research will be completed.

Hypothesis: When unaware whether a meat product is soy- or beef-based, consumers prefer soy-based meat.

Objectives: Create a study with 75 different people. 25 people would be told the difference between the two products before they eat the two burgers as a control group. The rest would be given both burgers, but they would not know which is which until after they fill out the survey. All 75 participants would be asked a series of questions to determine their preference and to rate each of the burgers.

Tasks:

1. Blindfold all the participants
2. Ask the control group preference between soy and beef burger.
3. Give each person a soy-bean burger and a beef burger.
4. Make sure the participant drinks water in between trying each burger.
5. Ask the participant to rate the burgers out of 10, and pick which was their favorite.
6. Ask them to rate the texture of each burger out out of 10.
7. Ask the other 50 participants, minus the control group, their preference of soybean vs beef.

Data Analysis:

- Break up the group into different demographics of age, race, gender, and religion.
- Observe trends between the different demographics and how it might have an influence on their preference.
- Gather mean ratings for taste and texture for each demographic combination within the blind and non-blind group.
- Use an ANOVA (analysis of variance) to see if demographic and the absence of visual stimuli have a significant effect on mean rating of taste and texture of soybean burgers and beef burgers.

References

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