**Project check-in # 1: Preliminary findings Report**

# 1. Preliminary Analysis

**Data Description:** The dataset is of the chemical characterization of 88 food waste substrates with specific importance on the principle nutrient components of the substrate i.e. carbohydrates, proteins, and lipids (fats). A snapshot of the dataset is shown below. Each food waste item, heretofore referred to as ‘substrate’, is assigned to a group based on rough commonalities of the substrate’s characteristics or what would be generally considered a food group in modern society i.e. products containing milk are all assigned to the group ‘Dairy Products’ while products containing animal flesh (non-fish) are assigned the group ‘Meat Products’. There are 15 groups across the 88 food substrates.

In the proposed analysis we will utilize the MATLAB based Anaerobic Digestion Model #1 (ADM1) to estimate the amount of biogas (methane) that can be produced from each food substrate. The model requires that the mass of the principal nutrients be provided, which can be determined by the characteristics listed in the table. Briefly: the amount of substrate material is determined by ‘TS.Perc’ or total solid percentage i.e. the mass of material that is not water, from the total solid percentage we then take the volatile solids percentage (VS.Perc) which is the fraction that can engage in anerobic digestion. Within the volatile solids we can then fraction out the principal nutrients (carbohydrates, proteins, and fats) by their listed percentages. The final mass of each of these will be what is fed into the model.

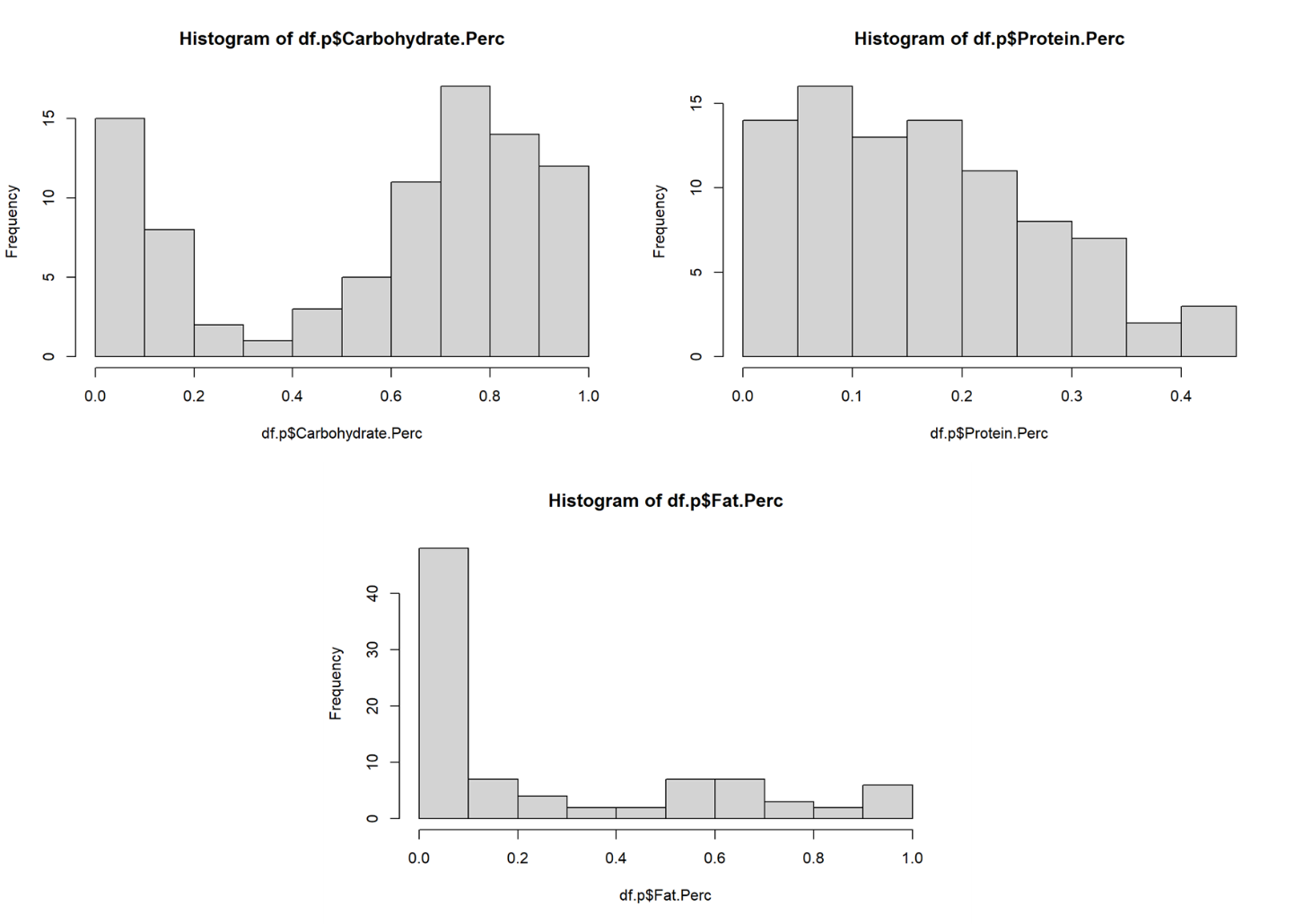
A screenshot of a computer program

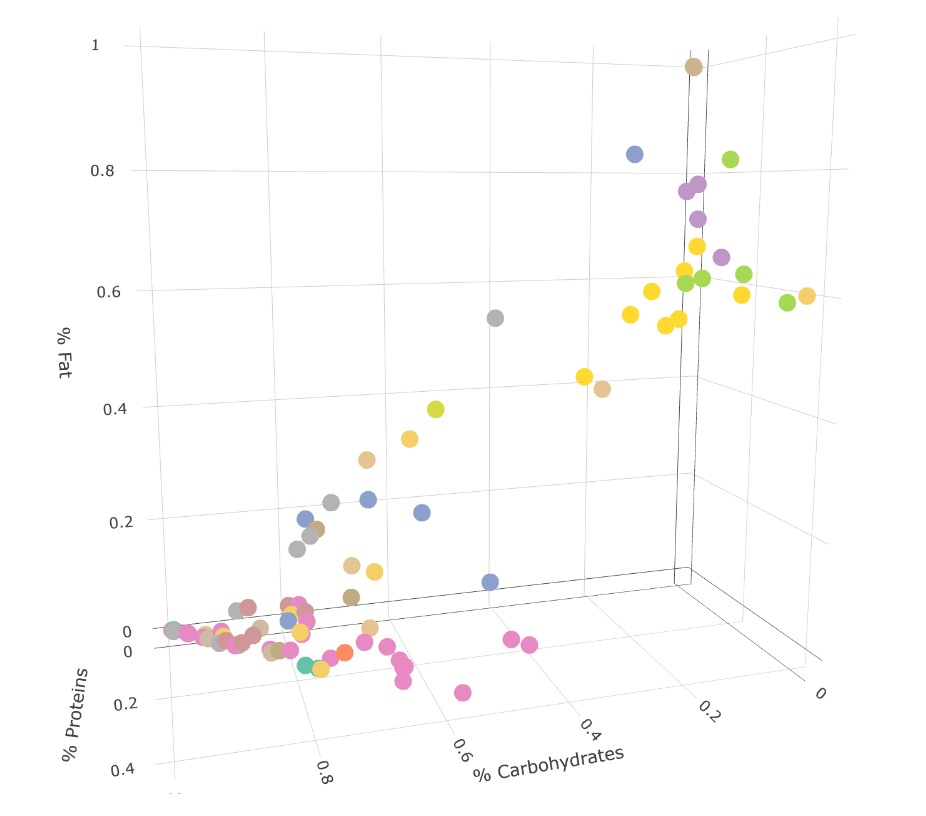
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**Initial Analysis:**

**Carbohydrate, Proteins, Fats Percentages**

To better understand the variability of each of the principal nutrients in the dataset, we developed histograms based on their percentages. We see that carbohydrates generally dominate the overall mass of the substrates with the majority of foods being >40% carbohydrates (by mass of VS). Proteins in general occupy a smaller percentage of the VS mass with the majority of foods having <20% proteins. In comparison, more than half the food substrates have 0-10% fats marking them as the lowest represented nutrient by mass with notable exceptions that are fat dominant such as oils, grease, and fatty dairy products.



To obtain more resolution on the overall fractionation of each of the principal nutrients we also plotted them in 3D space with each axis representing a % of the three nutrients as seen below. Due to the limitations of the program’s color palette it is difficult to infer distinctive groupings of the foods however we can see that the greatest percentage of food substrates is in the bottom left quadrant (blue circle, non-statistically based) i.e. possessing high carbohydrates, mid proteins, and low fats which corresponds to the observations of the histograms. A secondary cluster in the upper right (red circle, non-statistically based) describing low carbohydrates, mid proteins, and high fats is also in the spread.

**Mono-feed Biogas Output**

The primary output that will address our research questions is the production of methane biogas; and we are interested in both the rate and the overall quantity produced. Using the default parameters of the ADM1 model we ran an initial test under a batch feed (sequential i.e. a feed every n days) and a continuous feed regime. The model outputs the biogas as a rate (liters of biogas/day) over the reactor time (measured in days). The output for the two studies is below grouped by food category (table below).

|  |  |
| --- | --- |
| Food Classification | Symbol Used |
| Dairy Product | DP |
| Fats, oils, and grease | FOG |
| Ice Cream | IC |
| Fruit and Vegetable | FAV |
| Confectionary (canned good) | CCG |
| Cereals and Cereals Products | CP |
| Bakery Wares | BW |
| Meat and Meat Products | MP |
| Fish and Fish Products | FP |
| Eggs and Egg Products | EP |
| Sweeteners and Sweet Goods | SSG |
| Sauces, Spices, and Soups | SS |
| Beverages | BEV |
| Ready to eat food or restaurant waste | REWE |
| Other Expired Food | OT |

**Batch Feeding**

Briefly the batch feeding consisted of feeds of 1000 grams of total mass for all substrates. The results are output as a rate (q\_gas Liters/day) each day of the 100 day reactor. The output of the batch feeding (occurring day 0, 10, 30, 50, and 70) shows a consistent pattern across all food substrates but the magnitude varies both within and across food groups. The most consistently highly productive food groups are cereal products (CP) and bakery wares (BW) likely owing to their high percentage of carbohydrates. Meat products (MP), sweeteners and sweet goods (SSG), and ready to eat foods (REWE) are also highly productive but have greater variability across the foods within that category. Future analysis will investigate the chemical differences between foods within each group to identify possible associations explaining higher or lower production. An important aspect to remember for this analysis is that it utilized a base total mass (includes water and inerts) for each food item, which while more realistic in that food waste is typically presented as a bulk without consideration to the volatile solids, this does present great variability in the relative amounts of available material. For example, 1000 grams of bread has little water or inerts thus the overall VS amount is higher than butter which contains a larger amount of moisture. Normalizing the batch feed will be another aspect of consideration for future analysis.

A graph of different colored lines

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**Continuous Feed**

For the continuous feed analysis, the mass of feed was normalized to be a consistent total volatile solid amount of 300 grams and presented to the model as a constant daily rate of 300 grams of VS per Liter per day. This was done over the 100-day reactor timeline. The results are output as a rate (q\_gas Liters/day) each day of the 100-day reactor. Unlike the batch feed the reactors output an exponential growth pattern with a plateau. This can be thought of as the maximum rate of production for each food substrate under the given conditions. There appears to be lower variability between and across food groups than was observed in the batch reactor, which may be due to the fact that the substrate is not limited as it is in the batch reactors. The general range for production rate for all food substrates is between 700-1250 Liters of biogas/ day which may be lower than the batch feed but does incorporate a lower amount of substrate and shows stability which could be more desirable overall in a real world scenario.

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**Data Issues**

We currently have no issues with the data itself, our primary considerations that will require rectification are in how we treat the data specifically how we normalize it or scale to allow us to make direct comparisons. For example, in our preliminary batch and continuous feed analysis we utilized a bulk feed based on total mass for the batch analysis and a feed rate based on VS in the continuous analysis.