STAT-850 Final Project
Nutrition Recycalling Exploration on Inedible Food Components

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***Abstract*—**Food waste usually ends up in landfills that will generate methane, a greenhouse gas that speeds up the greenhouse effect. It is crucial to recycle the inedible refuse food components. In this study, we did data visualization and analysis to find refuse food components that can be potentially used as sources of nutrient extraction.

1 INTRODUCTION

Food waste is a classic problem and the main contributor to the greenhouse effect. Research from the U.S. Environmental Protection Agency (EPA) [1] shows that of the 136 million tons landfilled, almost 22% was food. The process of harvest, transportation, and production results in most food waste. Besides, food wasted by customers in the consumption process also accounts for a large part. According to the dataset of the wasted food, about 20% of meat is squandered. [4]

Protein, fat, carbohydrate, inorganic salt, and vitamin are the five main nutrient categories in meat. Protein has an important biological significance to the human body. The protein of meat is the complete protein, which can provide all kinds of amino acids needed by the human body. The fat in meat can supply calories and essential fatty acids for the human body. The main components of fat include triglycerides, fatty acids, and a small amount of lecithin, cholesterol, free fatty acids, fat-soluble pigments, etc. [5] However, some nutrient components from fat are not worth-recycling, such as cholesterol that is harmful to patients with hyperlipidemia or atherosclerosis. The carbohydrate content in meat is relatively low, therefore, it is not the nutrient category used to extract nutrients. Meat contains many minerals such as iron, phosphorus, potassium, sodium, copper, zinc, magnesium, etc. The total inorganic salt content of meat food is about 0.6% ~ 1.1%, the inorganic salt content of lean meat is higher than that of fat meat, and the content of offal is higher than that of lean meat. The last important nutrient category is a vitamin. Meat contains vitamin B, a little bit of fat-soluble vitamins A, D, and water-soluble vitamin C. The liver of some animals is a critical source of vitamin B12 (promote the metabolism) and vitamin A (conducive to growth, maintenance of the immune system, and vision), therefore it is extensively used in extracting these vitamins.

In this study, we will explore the potential recyclable food components and the number of different nutrients in those components to find a better way to recycle refuse food and save the environment. We aim at looking for a higher amount of discarded/inedible food components in meat with a higher amount of beneficial nutrients so that it is possible to extract nutrients from recycled food components and decrease food waste.

2 DATASET DESCRIPTION

FoodData is an integrated database that provides a food component and nutrient information. There are several tables in the original database, we only take three of them and merge the variables by **fdc_id**, which is a unique permanent identifier of food across tables. We would like to discover potential recycling of inedible food component which has relatively higher nutrient.

Three tables from the database are chosen for this project: one is *food_component.csv*, which contains several different constituent parts of food like bone, tissues. This table provides information about components, including their weight and whether it is refuse or not. The second table is *food_nutrient.csv*, which provides the nutrient value of a food. The third table is *nutrient.csv*. The nutrient defined as the chemical constituent of food (such as calcium, vitamin E) is officially recognized as essential to human health. The nutrient table contains nutrient names, units, and a unique code identifying a nutrient.

By combining three datasets and selecting several variables, generating a new dataset called **food_dataset** for further analysis. Description of variables in *food_dataset*:

component_name - The kind of component, e.g. bone

pct_weight - The weight of the component as a percentage of the total weight of the food

is_refuse - Whether the component is refuse, i.e. not edible

gram_weight - The weight of the component in grams

nutrient_name - Name of the nutrient

nutrient_amount - Amount of the nutrient per 100g of food. Specified in unit defined in the nutrient table.

min - The minimum amount

max - The maximum amount

median - The median amount

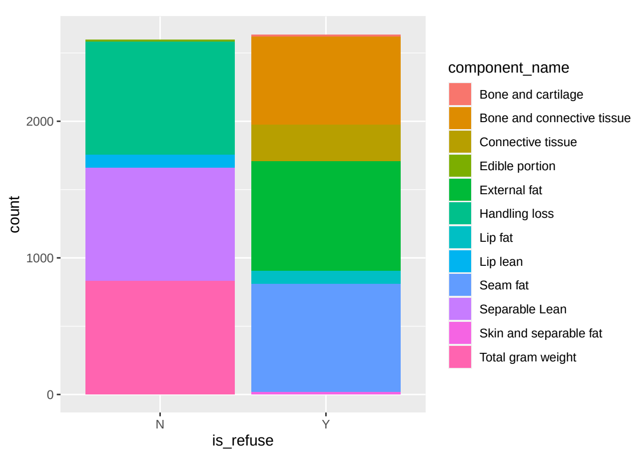
nutrient_unit - The standard unit of measure for the nutrient (per 100g of food)

nutrition_amount_in_component - The true value of nutrition amount in component

3 RESULTS

3.1 Refuse food component

The variable *is_refuse* in the original dataset has two levels: Y (is refuse) and N (non-refuse). Therefore, we can assign all components into two groups: one is refuse, another is not-refuse. Since our ultimate goal is to recycle the refuse components and explore the potential value of them, we plot the data by variable *is_refuse* to see what kind of component is refuse.

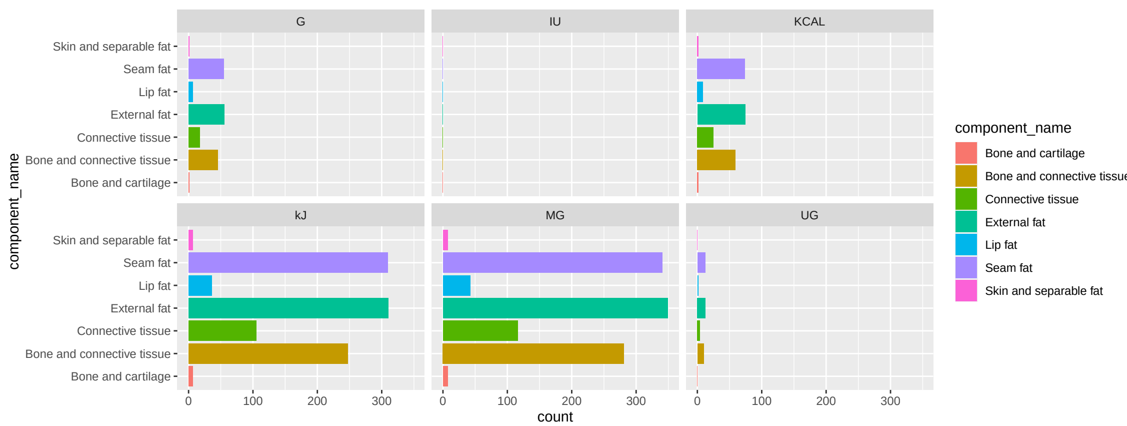


The bar chart above shows the detailed information of whether a component is refuse or not. The left bar is not refuse, contains components such as *separable lean*, *total gram weight*, *handling loss*, *edible portion*, *lip lean*. On the right-sidebar,the refuse components are mainly *bone and connective tissue*, *connective tissue*, *external fat*, *seam fat*, *bone and cartilage*, *lip fat*, *skin and separable fat*.

It is easy to see that all of the tissues and fats are refuses. Fat, tissue, and cartilage are components we can recycle and extract nutrition. We will only work on refuse components from this point.

3.2 Adjust units of nutrition amount

It is necessary to have uniform units for all components for statistical analysis of the nutrition amount. First of all, we would like to know how many units exist in the dataset and which one is the most commonly used.



From the plot above, We can see that the most common unit used for nutrition amount in the dataset is MG and KJ. We will adjust the mass unit to G, the energy unit to KJ. After adjustment, there exists mass unit *G*, energy unit *KJ*, and vitamin unit *IU*.

Mass unit adjustment: 1 g = 1000 mg = 1000000 ug

Energy unit adjustment: 1 KCAL = 4.184 KJ

3.3 Interactive graphics

Selecting the specific nutrient name in refused components can obtain the nutrient amount and weighted nutrient amount grouped by component name. Also, the unit of each nutrient follows the selectable nutrient name. It provides a more intuitive evaluation for the audience to observe the quantity difference within and among nutrients. The data visualization is conducted via shiny applet–interactive graphics.

For each nutrient, the nutrient amount is the sum of nutrient quantity in each component; it determines the total nutrient amount that we could recycle from the specific food component in different food. Since each component has different weights, we calculated the weighted amount of each nutrient to prompt intuitive comparison.

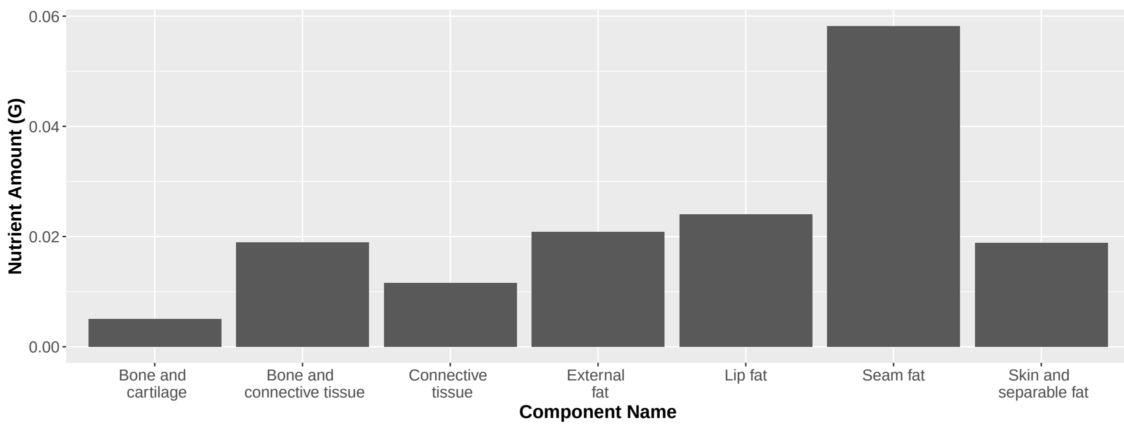
From the interactive graphics, we can see that the food component *Bone and connective tissue* contains the highest total amount for all nutrients, due to it exists in many food wastes. *Seam fat*, *external fat*, and *bone and connective tissue* are three main refuse components with the higher weighted nutrient amount. These are valuable recycling food components that we will explore later for nutrient extraction and utilization.

3.4 Potential recyclable refuse

Vitamins are substances that are needed by the human body to grow and develop [2]. Vitamin E is an antioxidant, which plays a role in the immune system and metabolic processes. It is a fat-soluble vitamin with several forms, but alpha-tocopherol is the only one used by the human body. [3] Alpha-tocopherol is also the form examined in this data set.

The Recommended Dietary Allowance (RDA) for vitamin E for males and females ages 14 years and older is 15 mg daily, including women who are pregnant. Lactating women need slightly more at 19 mg daily.

The plot below shows the vitamin E content in several refuse components.



There are two sources of Vitamin E: one is bone/tissue, including *Bone and cartilage*, *Bone and connective tissue*, *Connective tissue*; another is fat, including *external fat*, *lip fat*, *seam fat*, and *skin and separable fat*. We can see that fat generally contains a higher amount of Vitamin E. We run a t-test on components to test the visual evidence statistically. The null hypothesis is there is no significant difference between *bone/tissue* and *fat*. The test result shows that the p-value is 0.8238, so we fail to reject the null hypothesis and conclude that there is no difference between *bone/tissue* and *fat* components.

Therefore, we can extract Vitamin E from bone, tissue, and fat components. It would be reasonable to select the component with a minimum cost.

4 CONCLUSION

In this project, we explored potential recyclable food components by analyzing food datasets from FoodData Central. We found that bone and connective tissue, connective tissue, external fat, seam fat, bone and cartilage, lip fat, skin, and separable fat are good recycling sources of food waste. Among those food components, *Seam fat*, *external fat*, *bone, and connective tissue* have a higher amount of different nutrients, which can be wildly used as extraction materials for different kinds of nutrients. Vitamin E is an essential nutrient that supports our body health. By conducting a T-test on *bone/tissue* and *fat* components, we concluded that there is no difference between the amount of Vitamin E in these two components, indicating that both of them are valuable resources for Vitamin E extraction. By utilizing refuse food components efficiently, it is possible to reduce food waste and contribute to environmental protection.

REFERENCES

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