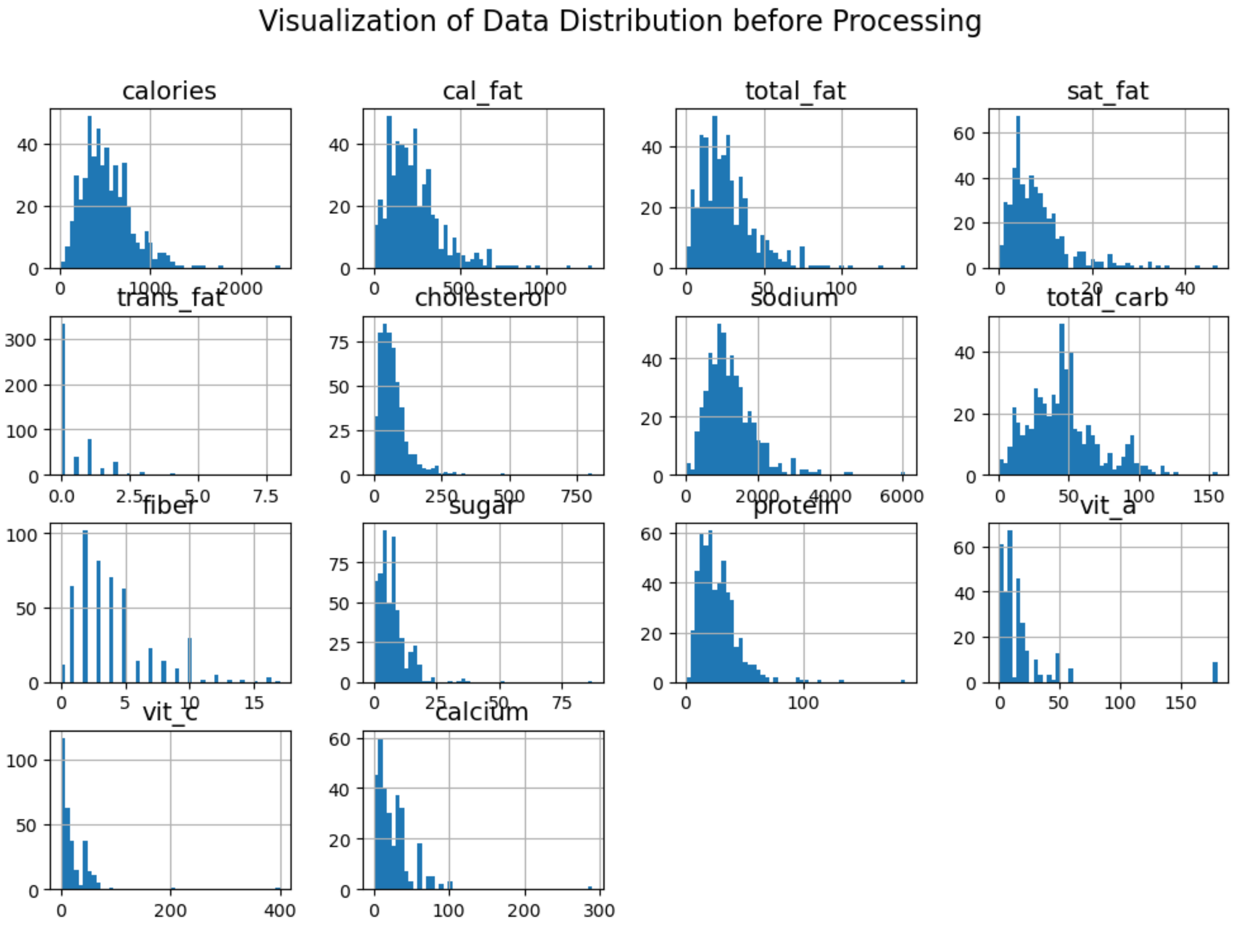
ASSIGNMENT 6 : CLUSTERING MODELS

IMPORT REQUIRED LIBRARIES

```
import pandas as pd
import numpy as np
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline, make_pipeline
from sklearn.preprocessing import OneHotEncoder, QuantileTransformer,
FunctionTransformer, MinMaxScaler, OrdinalEncoder, PowerTransformer,
RobustScaler
from sklearn.impute import KNNImputer
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.cluster import KMeans, DBSCAN, AgglomerativeClustering,
SpectralClustering
from sklearn import metrics
from sklearn.pipeline import make_pipeline, Pipeline
from sklearn.preprocessing import StandardScaler
import seaborn as sns
import matplotlib.pyplot as plt
import warnings

warnings.filterwarnings('ignore')
```

DATASET EXPLORATION

```
# Load & Examine Dataset
ff_df = pd.read_csv('fastfood.csv')

# Removing Duplicates
ff_df.drop_duplicates(inplace=True)

# Data Visualization
plt.rc('font', size=14)
plt.rc('axes', labelsize=14, titlesize=14)
plt.rc('legend', fontsize=14)
plt.rc('xtick', labelsize=10)
plt.rc('ytick', labelsize=10)
ff_df.hist(bins=50, figsize=(12, 8))
plt.suptitle("Visualization of Data Distribution before Processing",
fontsize=16)
plt.show()
```



RE-CATEGORIZE restaurant BASED ON FATCONTENT OF FOODS SOLD BY THEM

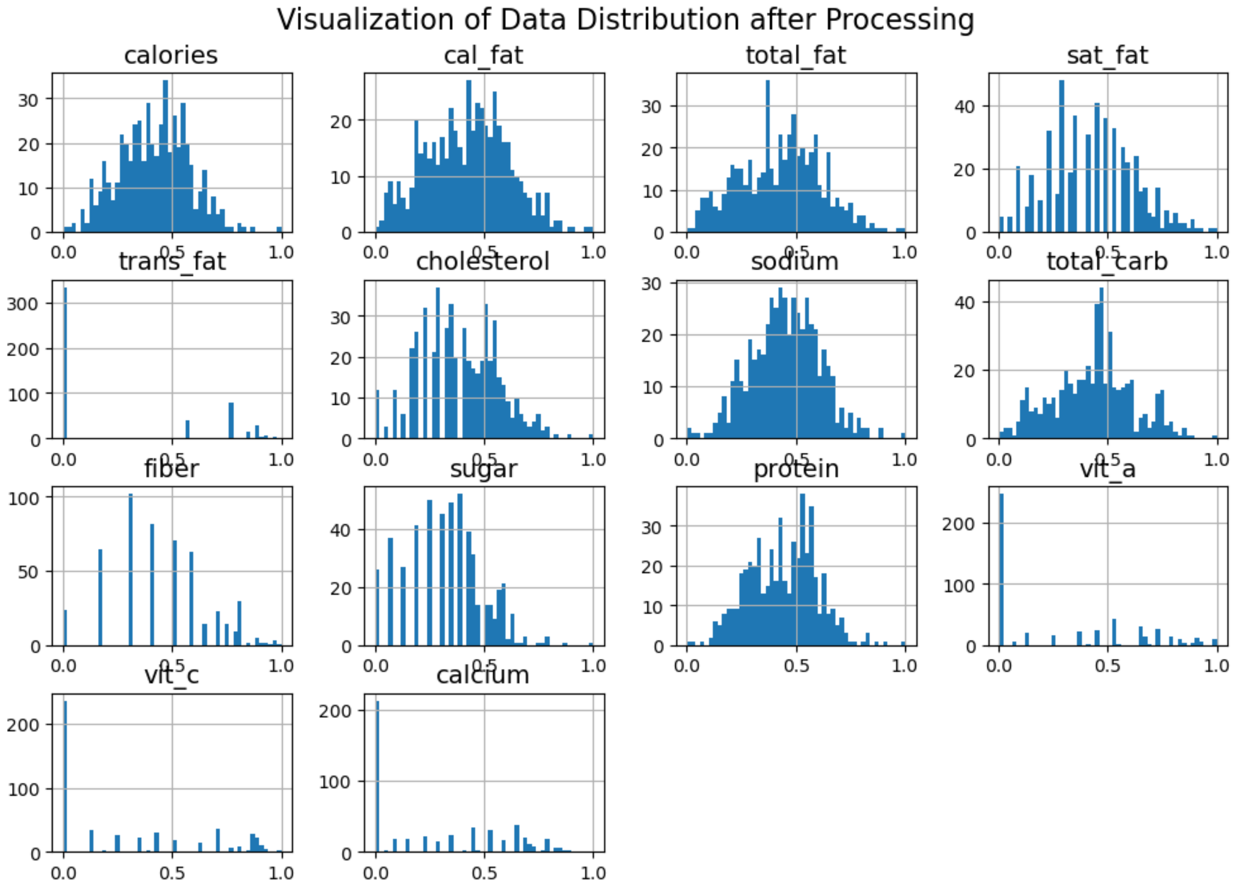
```
# replace NA with 0
ff_df = ff_df.fillna(0)
ff_df = ff_df.drop(['salad'], axis=1)

# Calculate the mean of total_fat for each unique category in
restaurant
mean_fat_by_restaurant = ff_df.groupby('restaurant')
['total_fat'].mean()
mean_fat_by_restaurant_sorted =
mean_fat_by_restaurant.sort_values(ascending=False)
print(mean_fat_by_restaurant_sorted)
```

```
restaurant
Sonic           37.641509
Burger King     36.814286
Mcdonalds       31.807018
Dairy Queen     28.857143
Arbys           26.981818
Taco Bell       20.858407
Subway          18.479167
Chick Fil-A     16.148148
Name: total_fat, dtype: float64

# Convert restaurant names to lowercase and strip whitespace
ff_df['restaurant'] = ff_df['restaurant'].str.lower().str.strip()

fat_categories = {
    'mcdonalds': 'HighFat',
    'sonic': 'HighFat',
    'burger king': 'HighFat',
    'arbys': 'MedFat',
    'dairy queen': 'MedFat',
    'subway': 'LowFat',
    'taco bell': 'MedFat',
    'chick fil-a': 'LowFat'
}

# Apply the mapping to the 'restaurant' column to update it with
fat_categories
ff_df['restaurant'] = ff_df['restaurant'].map(lambda x:
fat_categories.get(x, 'Unknown'))
```

PREPROCESSING

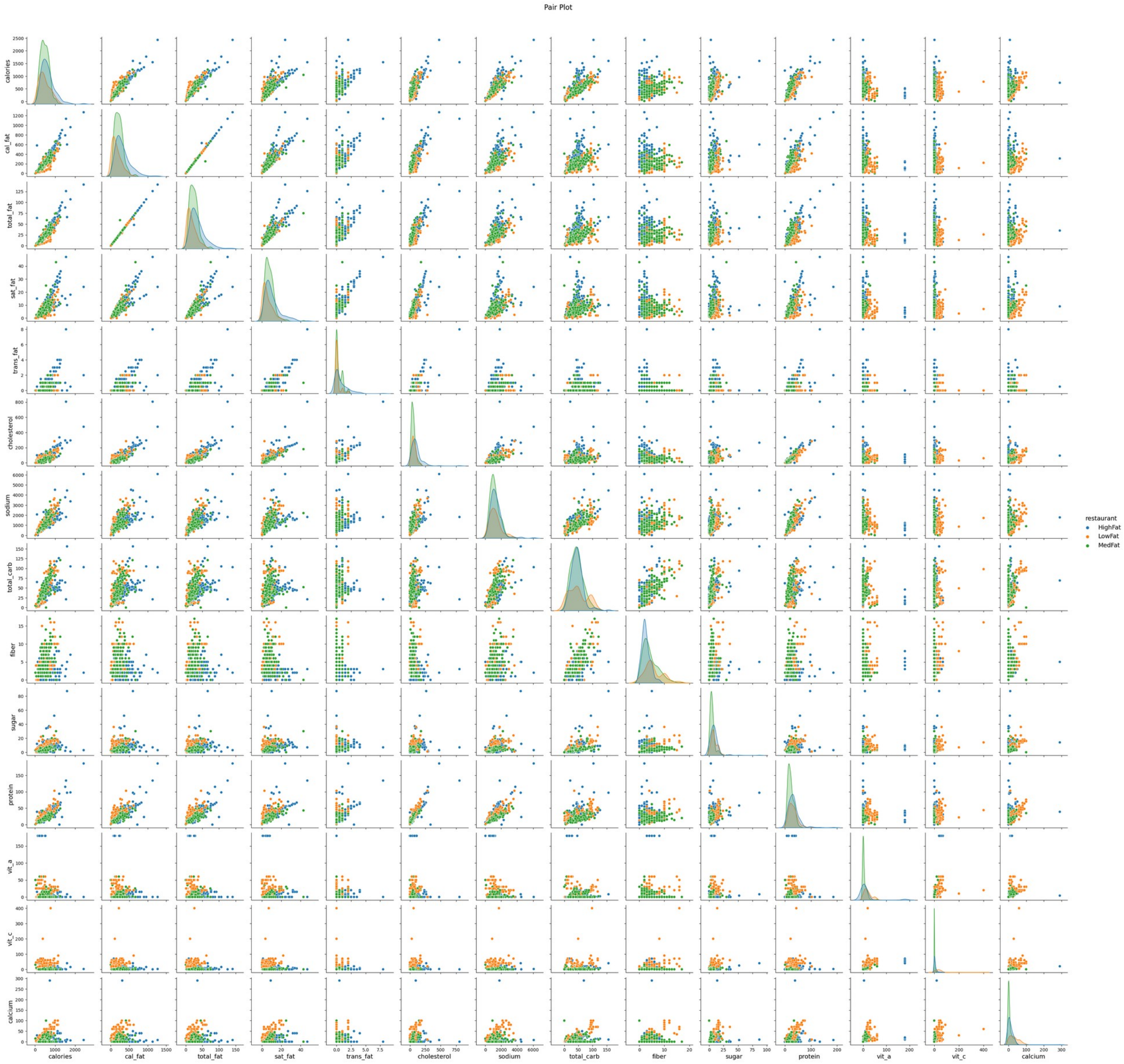
```
# Drop unwanted columns
ff_df_processed = ff_df.drop(['item', 'restaurant'], axis=1)

# Define the pipeline for numeric columns
pipeline = Pipeline([

    ("robust_scaler", RobustScaler()),
    ("std_scaler", StandardScaler()),
    ("log_transform", PowerTransformer(method='yeo-johnson')),
    ("scaler", MinMaxScaler())
])


ff_df_processed = pipeline.fit_transform(ff_df_processed)
```

```
# Convert the numpy array back to a DataFrame with appropriate column
names
ff_df_processed = pd.DataFrame(ff_df_processed,
columns=ff_df.drop(['item', 'restaurant'], axis=1).columns)

# DATA VISUALIZATION AFTER PROCESSING
plt.rc('font', size=14)
plt.rc('axes', labelsize=14, titlesize=14)
plt.rc('legend', fontsize=14)
plt.rc('xtick', labelsize=10)
plt.rc('ytick', labelsize=10)
ff_df_processed.hist(bins=50, figsize=(12, 8))
plt.suptitle("\n Visualization of Data Distribution after Processing",
fontsize=16)
plt.show()
```



PAIR PLOT

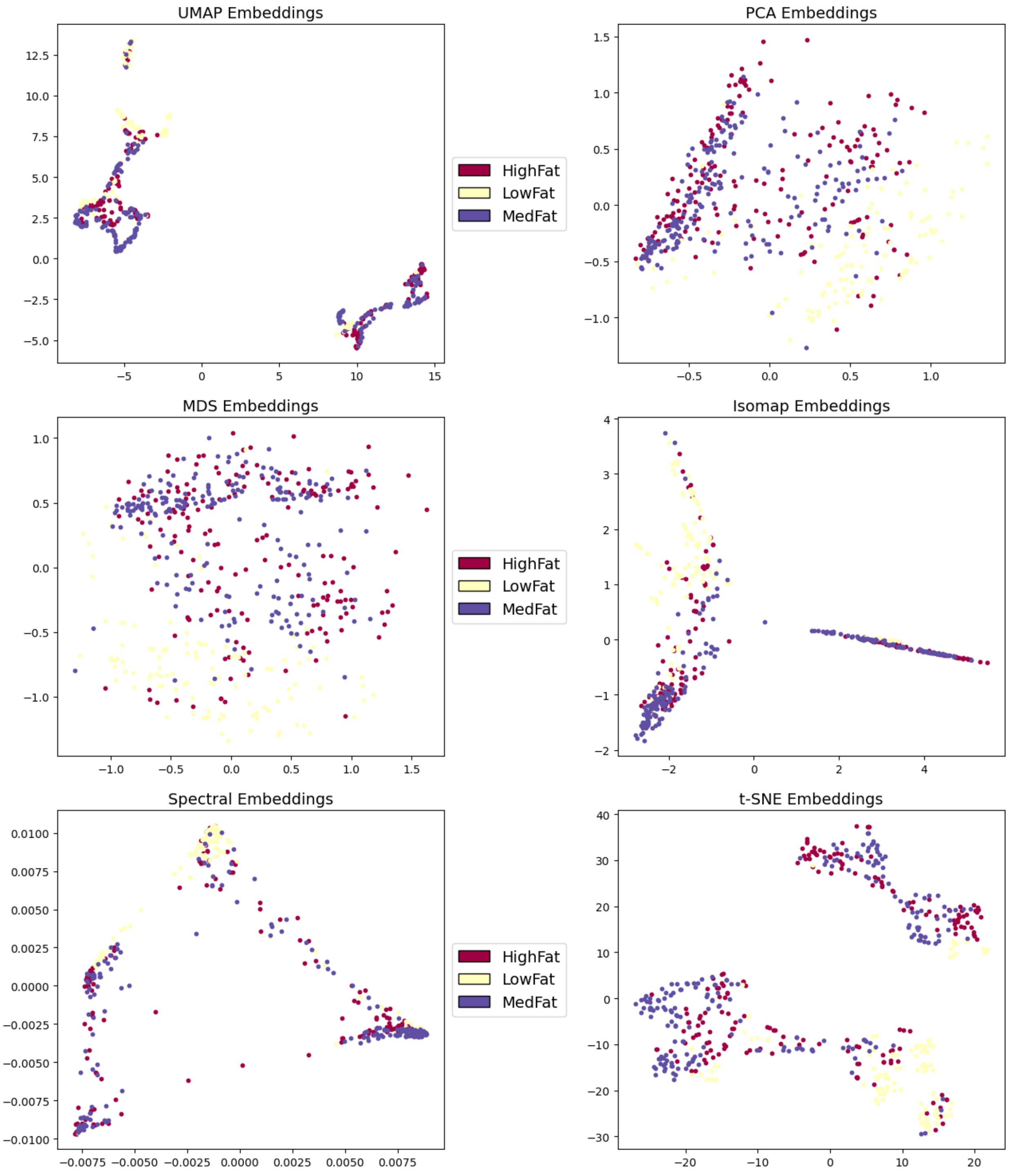
```
# Select numeric columns for pair plot
pair_plot = sns.pairplot(ff_df.drop(['item'], axis=1),
hue='restaurant')
pair_plot.fig.suptitle("Pair Plot", fontsize=16)
pair_plot.fig.subplots_adjust(top=0.95)
plt.show()
```



EMBEDDINGS

```
from sklearn.decomposition import PCA
import umap
import matplotlib.pyplot as plt
import numpy as np
from matplotlib.patches import Patch
from sklearn.manifold import MDS, Isomap, SpectralEmbedding, TSNE

# Now the data is transformed and we can apply PCA and UMAP
umap_embeddings = umap.UMAP(n_components=2,
random_state=42).fit_transform(ff_df_processed)
pca_embeddings = PCA(n_components=2,
random_state=42).fit_transform(ff_df_processed)

# Apply MDS
mds_embeddings = MDS(n_components=2,
random_state=42).fit_transform(ff_df_processed)

# Apply Isomap
isomap_embeddings =
Isomap(n_components=2).fit_transform(ff_df_processed)

# Apply Spectral Embedding
spectral_embeddings = SpectralEmbedding(n_components=2,
random_state=42).fit_transform(ff_df_processed)

# Apply t-SNE
tsne_embeddings = TSNE(n_components=2,
random_state=42).fit_transform(ff_df_processed)

# Define colors for the restaurants
restaurants = ff_df['restaurant'].astype('category').cat.categories
colors = plt.cm.Spectral(np.linspace(0, 1, len(restaurants)))
color_dict = {restaurant: color for restaurant, color in
zip(restaurants, colors)}

# Function to plot embeddings
def plot_embeddings(embeddings, title, subplot_index):
    plt.subplot(3, 2, subplot_index)
    for restaurant, color in color_dict.items():
        indices = ff_df['restaurant'] == restaurant
        plt.scatter(embeddings[indices, 0], embeddings[indices, 1],
c=[color], s=10)
    plt.title(title)
    # Add legend only for subplots 1, 3, and 5
    if subplot_index in [1, 3, 5]:
        legend_elements = [Patch(facecolor=color, edgecolor='k',
label=restaurant) for restaurant, color in color_dict.items()]
        plt.legend(handles=legend_elements, loc='center left',
bbox_to_anchor=(1, 0.5))

# Plotting the embeddings
plt.figure(figsize=(13, 15))

# UMAP Embeddings
plot_embeddings(umap_embeddings, "UMAP Embeddings", 1)
```

```python
# PCA Embeddings
plot_embeddings(pca_embeddings, "PCA Embeddings", 2)

# MDS Embeddings
plot_embeddings(mds_embeddings, "MDS Embeddings", 3)

# Isomap Embeddings
plot_embeddings(isomap_embeddings, "Isomap Embeddings", 4)

# Spectral Embeddings
plot_embeddings(spectral_embeddings, "Spectral Embeddings", 5)

# t-SNE Embeddings
plot_embeddings(tsne_embeddings, "t-SNE Embeddings", 6)

plt.tight_layout()
plt.show()
```



ANALYSIS OF EMBEDDINGS

UMAP Embeddings:

Provides clear separation of clusters. Captures the non-linear structure of the data effectively. Captures both local and global structure.

PCA Embeddings:

Linear method; less clear separation of clusters. Shows some grouping but misses complex relationships.

MDS Embeddings:

Linear method; similar to PCA in terms of performance. Some grouping but not as effective for non-linear data.

IsoMAP Embeddings:

Shows potential clusters but less distinct than UMAP and t-SNE. Captures non-linear structure to some extent.

Spectral Embeddings:

Non-linear method; good separation of clusters. Sensitive to the choice of parameters.

t-SNE Embeddings:

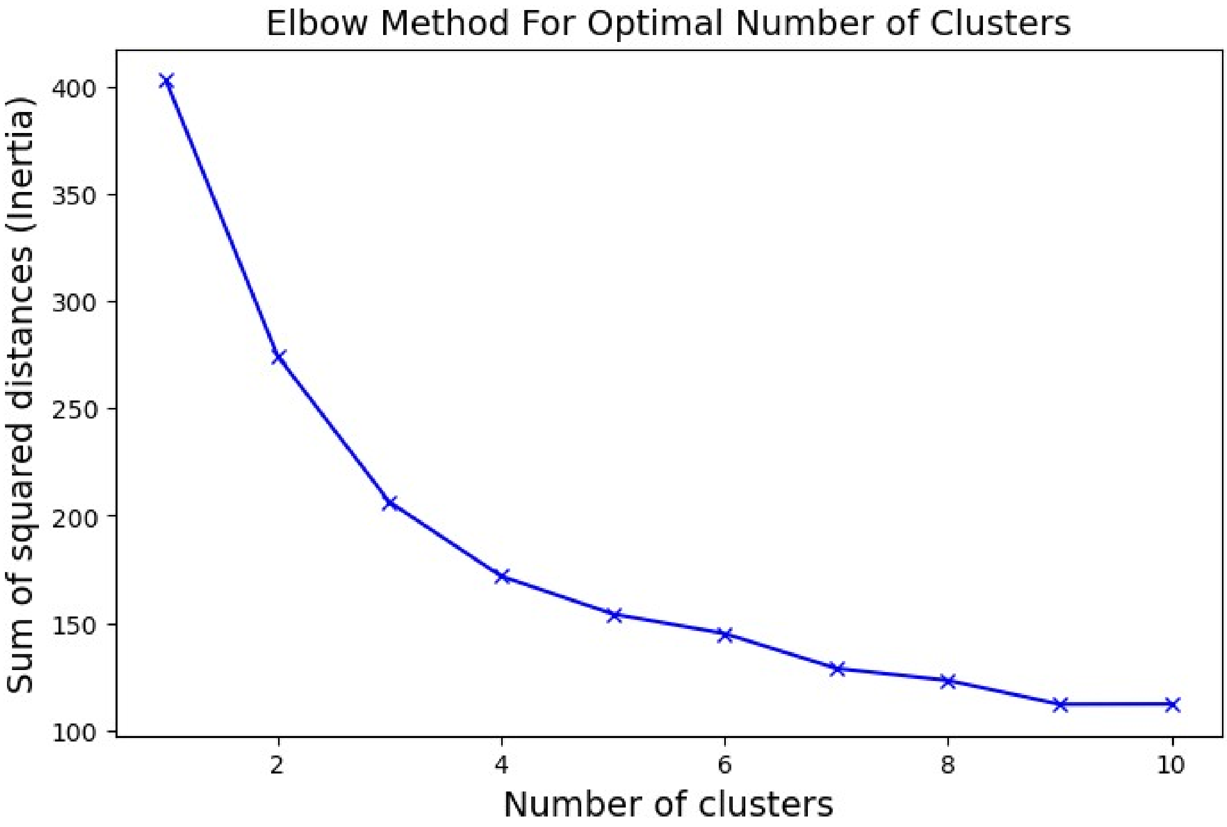
Non-linear method; excellent local structure capture. Clear separation of clusters but can be sensitive to parameters.

Conclusion:

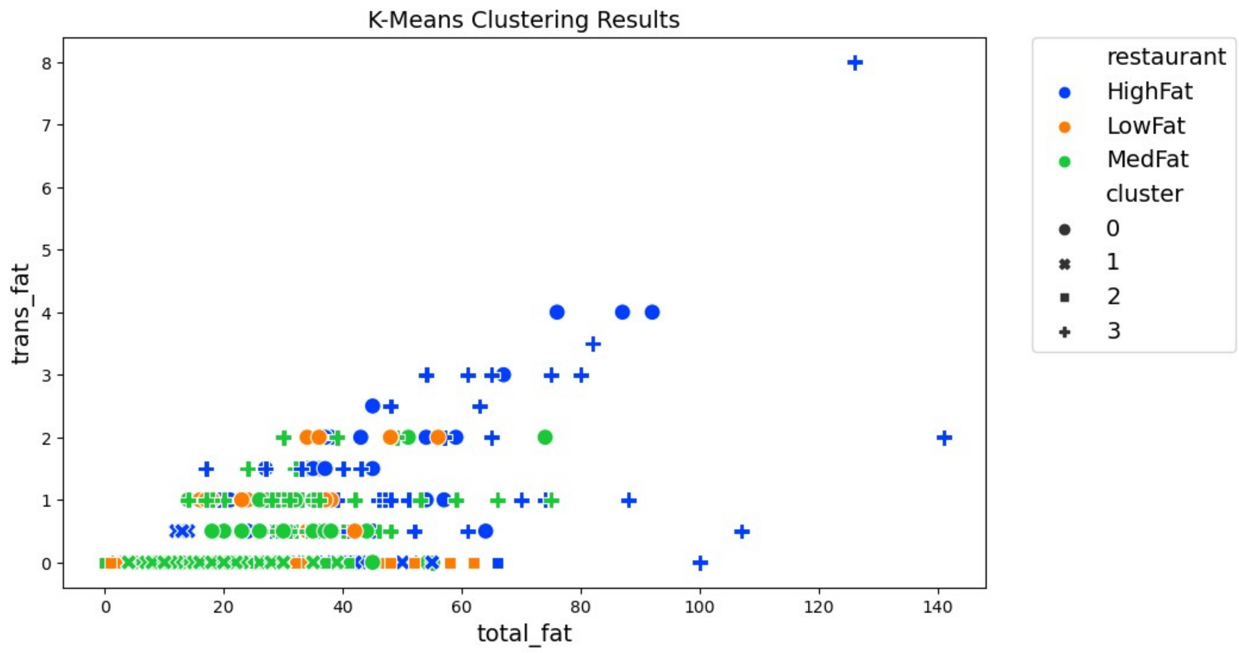
Best Embedding: UMAP provides the best overall separation and visualization of clusters in the dataset. Clustering: The data appears to have non-linear relationships, and UMAP and t-SNE effectively capture these structures. Number of Clusters: Approximately 3 distinct clusters are observed in the embeddings.

1. K MEANS CLUSTERING

```python
K = range(1, 11)

# List to store the sum of squared distances
ssd = []

for k in K:
    kmeans = KMeans(n_clusters=k)
    kmeans.fit(ff_df_processed)
    ssd.append(kmeans.inertia_)

# Plot the elbow chart
plt.figure(figsize=(8, 5))
plt.plot(K, ssd, 'bx-')
plt.xlabel('Number of clusters')
plt.ylabel('Sum of squared distances (Inertia)')
plt.title('Elbow Method For Optimal Number of Clusters')
plt.show()
```



```
# Build the k-means clustering model
kmeans = KMeans(n_clusters=4, random_state=42)
ff_df['cluster'] = kmeans.fit_predict(ff_df_processed)

    plt.figure(figsize=(10, 6))
    sns.scatterplot(x='total_fat', y='trans_fat', hue='restaurant', 
style='cluster', data=ff_df, palette='bright', s=100)
    plt.title('K-Means Clustering Results')
    plt.xlabel('total_fat')
    plt.ylabel('trans_fat')
    plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
    plt.show()
```



INTERPRETATION

Cluster 0: Total fat content between 20 and 75 while trans_fat ranges from 0 to 4. Restaurants that have been classified as HighFat & MedFat food items seller fall under this category

Cluster 1: Total fat content between 0 and 68 while trans_fat ranges from 0 to 0.5. Majority of Restaurants that have been classified as MedFat food items seller fall under this category

Cluster 2: Total fat content between 0 and 60 while trans_fat is just 0. Majority of Restaurants that have been classified as MedFat food items seller fall under this category

Cluster 3: Total fat content between 20 and 140 while trans_fat ranges from 0 to 8. Some of the Restaurants that have been classified as MedFat food items seller & majority of sellers of HighFat foods fall under this category

```
# List members of each cluster by instance_name
clusters = ff_df.groupby('cluster')['item'].apply(list).reset_index()
for index, row in clusters.iterrows():
    print(f"Cluster {row['cluster']}:")
    for instance in row['item']:
        print(f"  - {instance}")
```

```
Cluster 0:
  - Single Bacon Smokehouse Burger
  - Double Bacon Smokehouse Burger
  - Grilled Bacon Smokehouse Chicken Sandwich
  - Crispy Bacon Smokehouse Chicken Sandwich
  - Big Mac
  - Double Cheeseburger
  - Double Quarter Pounder® with Cheese
  - Garlic White Cheddar Burger
  - Maple Bacon Dijon 1/4 lb Burger
  - Crispy Maple Bacon Dijon Chicken Sandwich
  - McDouble
  - Pico Guacamole 1/4 lb Burger
  - Quarter Pounder® with Cheese
  - Signature Sriracha Burger
  - Sweet BBQ Bacon 1/4 lb Burger
  - Crispy Sweet BBQ Bacon Chicken Sandwich
  - Hatch Green Chile Cheeseburger
  - Jalapeno Burger
  - Jr. Chili Cheeseburger
  - Jr. Deluxe Cheeseburger
  - Jr. Double Cheeseburger
  - Sonic Bacon Cheeseburger (w/mayo)
  - Sonic Burger W/ Mustard
  - Sonic Burger W/ Ketchup
  - Sonic Burger W/ Mayonnaise
  - Sonic Cheeseburger W/ Mustard
  - Sonic Cheeseburger W/ Ketchup
  - Sonic Cheeseburger W/ Mayonnaise
  - Super Sonic Bacon Double Cheeseburger (w/mayo)
  - Super Sonic Double Cheeseburger W/ Mustard
  - Super Sonic Double Cheeseburger W/ Ketchup
  - Super Sonic Double Cheeseburger W/ Mayo
  - Super Sonic Jalapeno Double Cheeseburger
  - 5 Piece Super Crunch Chicken Strip Dinner
  - Ultimate Chicken Club
  - Footlong Quarter Pound Coney
  - Classic French Dip & Swiss/Au Jus
  - Pecan Chicken Salad Sandwich
  - Reuben Sandwich
  - Roast Beef Gyro
  - Roast Turkey, Ranch & Bacon Sandwich
  - Roast Turkey, Ranch & Bacon Wrap
  - Smokehouse Brisket
  - Super Roast Beef
  - 1/2 lb. FlameThrower® GrillBurger
  - 1/2 lb. GrillBurger with Cheese
  - 1/4 lb. Bacon Cheese GrillBurger
  - 1/4 lb. GrillBurger with Cheese
  - Original Cheeseburger
  - Original Double Cheeseburger
  - Chili Cheese Dog
  - Regular Cheese Curds
  - Deluxe Cheeseburger
  - Deluxe Double Cheeseburger
  - Deluxe Double Hamburger
  - Deluxe Hamburger
  - DQ Ultimate® Burger
  - 6" Big Philly Cheesesteak
  - Footlong Big Philly Cheesesteak
  - 6" Chicken & Bacon Ranch Melt
  - Footlong Chicken & Bacon Ranch Melt
  - 6" Meatball Marinara
  - Footlong Meatball Marinara
  - 6" Spicy Italian
  - Footlong Spicy Italian
  - 6" Turkey Italiano Melt (with Provolone)
  - Footlong Turkey Italiano Melt (with Provolone)
  - Big Philly Cheesesteak Salad
  - Chicken & Bacon Ranch Melt Salad (includes Ranch dressing)
  - Meatball Marinara Salad
  - Spicy Italian Salad
  - Chipotle Southwest Steak & Cheese Wrap
  - Rotisserie-Style Chicken Caesar Wrap
  - Turkey, Bacon & Guacamole Wrap
  - Beef Crunchy Cheesy Core Burrito
  - Loaded Taco Burrito
  - Beef Spicy Cheesy Core Burrito
  - Cool Ranch Habanero Double Stacked Taco
  - Double Chalupa
  - Spicy Double Chalupa
  - Double Cheesy Gordita Crunch
  - Crispy Chicken Quesadilla
  - Steak Quesalupa
  - Chicken Quesalupa
  - Beef Quesalupa
  - Stacker
  - Original Triple Double Crunchwrap
  - Spicy Triple Double Crunchwrap
Cluster 1:
  - Cheeseburger
  - Classic Chicken Sandwich
  - Filet-O-Fish®
  - Hamburger
  - Lobster Roll
  - McChicken
  - McRib
  - 3 piece Buttermilk Crispy Chicken Tenders
  - 4 piece Buttermilk Crispy Chicken Tenders
  - 4 Piece Chicken McNuggets
  - 6 Piece Chicken McNuggets
  - 10 Piece Chicken McNuggets
  - 20 Piece Chicken McNuggets
  - Chick-n-Slider
  - 1 Piece Chick-n-Strips
  - 2 Piece Chick-n-Strips
  - 3 Piece Chick-n-Strips
  - 4 piece Chick-n-Strips
  - 4 piece Chicken Nuggets
  - 6 piece Chicken Nuggets
  - 8 piece Chicken Nuggets
  - 12 piece Chicken Nuggets
  - Chicken Sandwich
  - 4 Piece Grilled Chicken Nuggets
  - 6 Piece Grilled Chicken Nuggets
  - 8 piece Grilled Chicken Nuggets
  - 12 Piece Grilled Chicken Nuggets
  - Spicy Chicken Sandwich
  - Chicken Parmesan Meal Kit
  - Chicken Strip Sandwich
  - 3 Piece Crispy Chicken Tender Dinner
  - 5 Piece Crispy Chicken Tender Dinner
  - Small Jumbo Popcorn Chicken
  - Small Spicy Jumbo Popcorn Chicken
  - Large Spicy Jumbo Popcorn Chicken
  - 3 Piece Super Crunch Chicken Strips
  - 4 Piece Super Crunch Chicken Strips
  - 5 Piece Super Crunch Chicken Strips
  - Traditional Ultimate Chicken Sandwich
  - All Beef All-american Style Dog – 6"
  - All Beef Chicago Dog – 6"
  - All Beef Chili Cheese Coney – 6"
  - All Beef New York Dog – 6"
  - All Beef Regular Hot Dog – 6"
  - Cheesy Bacon Pretzel Dog - 6 In.
  - Corn Dog
  - The Original Pretzel Dog
  - Arby's Melt
  - Bourbon BBQ Chicken Sandwich
  - Bourbon BBQ Steak Sandwich
  - Buttermilk Buffalo Chicken Sandwich
  - Buttermilk Chicken Bacon & Swiss
  - Buttermilk Chicken Cordon Bleu Sandwich
  - Buttermilk Crispy Chicken Sandwich
  - Classic Roast Beef
  - Greek Gyro
  - Ham & Swiss Melt
  - 2 piece Prime-Cut Chicken Tenders
  - 3 piece Prime-Cut Chicken Tenders
  - 5 piece Prime-Cut Chicken Tenders
  - Turkey Avocado Club
  - Buffalo Chicken Slider
  - Chicken Tender 'n Cheese Slider
  - Corned Beef 'n Cheese Slider
  - Ham 'n Cheese Slider
  - Jalapeno Roast Beef 'n Cheese Slider
  - Pizza Slider
  - Roast Beef 'n Cheese Slider
  - Turkey 'n Cheese Slider
  - Greek Gyro Salad
  - Super Greek Salad
  - Bacon Cheeseburger
  - Bacon Cheeseburger Deluxe
  - Bacon King Jr
  - Cheeseburger
  - Double Hamburger
  - Hamburger
  - Rodeo Burger
  - WHOPPER JR. w/o Cheese
  - Bacon Cheddar Ranch Chicken Salad w/ grilled Chicken & Dressing
  - Bacon Cheddar Ranch Chicken Salad w/ crispy Chicken & Dressing
  - Chicken BLT Salad w/ Grilled Chicken
  - Chicken Caesar Salad w/ Grilled Chicken
  - Chicken Caesar Salad w/ Crispy Chicken
  - Chicken, Apple & Cranberry Salad w/ Grilled Chicken
  - Chicken, Apple & Cranberry Salad w/ Crispy Chicken
  - Garden Grilled Chicken Salad w/ Grilled Chicken, no dressing
  - Garden Grilled Chicken Salad w/ Crispy Chicken, no dressing
  - Side Caesar Salad with dressing
  - Side Garden Salad and Avocado Ranch Dressing
  - BBQ Bacon Crispy Chicken Sandwich
  - Big Fish Sandwich
  - BK VEGGIE Burger
  - Chicken Burger
  - Chicken Cordon Bleu Sandwich
  - 4 Piece Chicken Nuggets
  - 6 Piece Chicken Nuggets
  - 20 Piece Chicken Nuggets
  - Chicken Nuggets (10pc)
  - Chicken Parmesan Sandwich
  - Crispy Chicken Jr.
  - Grilled Chicken Sandwich
  - Jalapeno Chicken Fries
  - Pretzel Chicken Fries
  - Rodeo Crispy Chicken Sandwich
  - 4 Piece Spicy Chicken Nuggets
  - Spicy Chicken Nuggets
  - Spicy Crispy Chicken Jr.
  - Spicy Crispy Chicken Sandwich
  - Spicy Crispy Jalapeno Chicken Sandwich
  - Barbecue Pork Sandwich
  - Breaded Mushrooms
  - Corn Dog
  - Crispy Fish Sandwich
  - Pork Tenderloin Sandwich
  - 3 chicken strips Chicken Strips
  - Chicken Bacon Ranch Sandwich
  - Chicken Mozzarella Sandwich
  - Crispy Chicken BLT Salad
  - Crispy Chicken Garden Greens Salad
  - Crispy Chicken Wrap
  - Grilled Chicken BLT Salad
  - Grilled Chicken Garden Greens Salad
  - Grilled Chicken Wrap
  - Turkey BLT Sandwich
  - 7-Layer Burrito
  - Bean Burrito
  - Beefy 5-Layer Burrito
  - Beefy Fritos® Burrito
  - Black Bean Burrito
  - Burrito Supreme® – Beef
  - Burrito Supreme® - Chicken
  - Burrito Supreme® - Steak
  - Cantina Power Burrito - Chicken
  - Cantina Power Burrito - Steak
  - Cantina Power Burrito - Veggie
  - Cheesy Bean and Rice Burrito
  - Chicken Quesarito
  - Shredded Chicken Burrito
  - Smothered Burrito - Shredded Chicken
  - Triple Melt Burrito
  - XXL Grilled Stuft Burrito - Chicken
  - Chicken Soft Taco
  - Cool Ranch® Doritos® Double Decker® Taco
  - Cool Ranch® Doritos® Locos Taco
  - Cool Ranch® Doritos® Locos Taco Supreme
  - Crunchy Taco
  - Crunchy Taco Supreme®
  - Double Decker® Taco
  - DOUBLE DECKER® Taco Supreme®
  - Spicy Sweet Double Stacked Taco
  - Nacho Crunch Double Stacked Taco
  - Fiery Doritos® Double Decker® Taco
  - Fiery Doritos® Locos Taco
  - Fiery Doritos® Locos Taco Supreme
  - Grilled Steak Soft Taco
  - Nacho Cheese Doritos® Double Decker® Taco
  - Nacho Cheese Doritos® Locos Tacos
  - Nacho Cheese Doritos® Locos Tacos Supreme
  - Soft Taco Supreme® – Beef
  - Soft Taco-Beef
  - Spicy Potato Soft Taco
  - Chalupa Supreme® - Chicken
  - Chalupa Supreme® - Steak
  - Chalupa Supreme®–Beef
  - Wild Naked Chicken Chalupa
  - Mild Naked Chicken Chalupa
  - Fresco Bean Burrito
  - Fresco Burrito Supreme® – Chicken
  - Fresco Burrito Supreme® – Steak
  - Fresco Chicken Soft Taco
  - Fresco Crunchy Taco
  - Fresco Grilled Steak Soft Taco
  - Fresco Soft Taco
  - Gordita Supreme® – Beef
  - Gordita Supreme® - Chicken
  - Gordita Supreme® - Steak
  - Nachos BellGrande®
  - Nachos Supreme
  - Triple Layer Nachos
  - Triple Melt Nachos
  - Beefy Cheddar Crunchwrap Slider
  - Beefy Mini Quesadilla
  - Beefy Nacho Griller
  - BLT Crunchwrap Slider
  - Cantina Power Bowl - Chicken
  - Cantina Power Bowl - Steak
  - Cantina Power Bowl - Veggie
  - Cheese Roll-Up
  - Chipotle Crispy Chicken Griller
  - Crunchwrap Supreme®
  - Double Tostada
  - Loaded Potato Griller
  - Shredded Chicken Mini Quesadilla
  - Spicy Chicken Crunchwrap Slider
  - Spicy Tostada
  - Fiesta Taco Salad-Chicken
Cluster 2:
  - Artisan Grilled Chicken Sandwich
  - Grilled Garlic White Cheddar Chicken Sandwich
  - Crispy Garlic White Cheddar Chicken Sandwich
  - Grilled Maple Bacon Dijon Chicken Sandwich
  - Grilled Pico Guacamole Chicken Sandwich
  - Crispy Pico Guacamole Chicken Sandwich
  - Premium Buttermilk Crispy Chicken Deluxe Sandwich
  - Premium Crispy Chicken Deluxe Sandwich
  - Grilled Signature Sriracha Chicken Sandwich
  - Crispy Signature Sriracha Chicken Sandwich
  - Grilled Sweet BBQ Bacon Chicken Sandwich
  - 4 piece Sweet N' Spicy Honey BBQ Glazed Tenders
  - 6 piece Sweet N' Spicy Honey BBQ Glazed Tenders
  - 10 piece Sweet N' Spicy Honey BBQ Glazed Tenders
  - Premium Asian Salad w/o Chicken
  - Premium Asian Salad w/ Grilled Chicken
  - Premium Asian Salad w/ Crispy Chicken
  - Premium Bacon Ranch Salad w/o Chicken
  - Premium Bacon Ranch Salad w/ Grilled Chicken
  - Premium Bacon Ranch Salad w/ Crispy Chicken
  - Premium Southwest Salad w/o Chicken
  - Premium Southwest Salad w/ Grilled Chicken
  - Premium Southwest Salad w/ Crispy Chicken
  - Chargrilled Chicken Club Sandwich
  - Chargrilled Chicken Sandwich
  - Chicken Deluxe
  - 30 piece Chicken Nuggets
  - Chicken Salad Sandwich
  - Spicy Grilled Chicken Sub Sandwich
  - Regular Grilled Chicken Sub Sandwich
  - Smokehouse BBQ Bacon Sandwich
  - Spicy Deluxe
  - Chargrilled Chicken Cool Wrap
  - Veggie Burger W/ Ketchup
  - Veggie Burger With Mustard
  - Veggie Burger W/ Mustard
  - Grilled Asiago Caesar Chicken Club Sandwich
  - Crispy Asiago Caesar Chicken Club Sandwich
  - Grilled Chicken Sandwich
  - Crispy Chicken Sandwich
  - Deluxe Ultimate Chicken Sandwich
  - Arby-Q Sandwich
  - Grand Turkey Club
  - Roast Turkey & Swiss Sandwich
  - Roast Turkey & Swiss Wrap
  - Turkey Gyro
  - Chopped Side Salad
  - Crispy Chicken Farmhouse Salad
  - Roast Turkey Farmhouse Salad
  - Crispy Chicken Sandwich
  - Grilled Chicken Sandwich
  - Side Salad
  - 6" B.L.T.
  - Footlong B.L.T.
  - 6" BBQ Rib Sandwich
  - Footlong BBQ Rib Sandwich
  - 6" Big Hot Pastrami
  - Footlong Big Hot Pastrami
  - Kids Mini Sub Black Forest Ham
  - 6" Black Forest Ham
  - Footlong Black Forest Ham
  - 6" Carved Turkey
  - Footlong Carved Turkey
  - 6" Carved Turkey & Bacon w/ Cheese
  - Footlong Carved Turkey & Bacon w/ Cheese
  - 6" Chicken Pizziola Melt
  - Footlong Chicken Pizziola Melt
  - 6" Cold Cut Combo
  - Footlong Cold Cut Combo
  - 6" Corned Beef Reuben
  - Footlong Corned Beef Reuben
  - 6" Italian B.M.T.
  - Footlong Italian B.M.T.
  - 6" Italian Hero
  - Footlong Italian Hero
  - 6" Oven Roasted Chicken
  - Footlong Oven Roasted Chicken
  - Kids Mini Sub Roast Beef
  - 6" Roast Beef
  - Footlong Roast Beef
  - 6" Rotisserie Style Chicken
  - Footlong Rotisserie Style Chicken
  - 6" Steak and Cheese
  - Footlong Steak and Cheese
  - 6" Subway Club
  - Footlong Subway Club
  - 6" Subway Melt (includes cheese)
  - Footlong Subway Melt (includes cheese)
  - 6" Subway Seafood Sensation
  - Footlong Subway Seafood Sensation
  - 6" Sweet Onion Chicken Teriyaki
  - Footlong Sweet Onion Chicken Teriyaki
  - 6" Tuna
  - Footlong Tuna
  - 6" Turkey & Bacon Avocado
  - Footlong Turkey & Bacon Avocado
  - Kids Mini Sub Turkey Breast
  - 6" Turkey Breast
  - Footlong Turkey Breast
  - 6" Turkey Breast & Ham
  - Footlong Turkey Breast & Ham
  - Kids Mini Sub Veggie Delite
  - 6" Veggie Delite
  - Footlong Veggie Delite
  - 6" Veggie Patty
  - Footlong Veggie Patty
  - Autumn Carved Turkey Salad
  - B.L.T. Salad
  - Big Hot Pastrami Melt Salad
  - Black Forest Ham Salad
  - Buffalo Chicken Salad (with Ranch dressing)
  - Carved Turkey & Bacon w/ Cheese Salad
  - Carved Turkey Salad
  - Cold Cut Combo Salad
  - Double Chicken Salad
  - Italian B.M.T.® Salad
  - Italian Hero Salad
  - Oven Roasted Chicken Salad
  - Roast Beef Salad
  - Steak & Cheese Salad
  - Subway Club Salad
  - Subway Melt® Salad
  - Sweet Onion Chicken Teriyaki Salad
  - Tuna Salad
  - Turkey Breast & Ham Salad
  - Turkey Breast Salad
  - Veggie Delite Salad
  - Cheese & Veggies Pizza
  - Cheese Pizza
  - Pepperoni Pizza
  - Sausage Pizza
  - Chicken Crunchy Cheesy Core Burrito
  - Steak Crunchy Cheesy Core Burrito
  - Chicken Spicy Cheesy Core Burrito
  - Steak Spicy Cheesy Core Burrito
  - Nacho Fries Bellgrande
  - Chickstar
Cluster 3:
  - 6 piece Buttermilk Crispy Chicken Tenders
  - 10 piece Buttermilk Crispy Chicken Tenders
  - 12 piece Buttermilk Crispy Chicken Tenders
  - 20 piece Buttermilk Crispy Chicken Tenders
  - 40 piece Chicken McNuggets
  - Chicken Enchiladas Meal Kit
  - Jr. Burger
  - Jr. Deluxe Burger
  - Buffalo Dunked Ultimate Chicken Sandwich
  - Garlic Parmesan Dunked Ultimate Chicken Sandwich
  - Large Jumbo Popcorn Chicken
  - 3 Piece Super Crunch Chicken Strip Dinner
  - 4 Piece Super Crunch Chicken Strip Dinner
  - Beef 'n Cheddar Classic
  - Beef 'n Cheddar Mid
  - Bourbon BBQ Brisket Sandwich
  - Double Roast Beef
  - Fire-Roasted Philly Steak
  - Half Pound Beef 'n Cheddar Sandwich
  - Half Pound French Dip & Swiss
  - Half Pound Roast Beef Sandwich
  - Loaded Italian Sandwich
  - Pecan Chicken Salad Flatbread
  - Smoke Mountain w/ Beef Short Rib
  - Smokehouse Beef Short Rib Sandwich
  - Three Cheese Steak Sandwich
  - Triple Decker Sandwich
  - Ultimate BLT
  - American Brewhouse King
  - Bacon & Swiss Sourdough King
  - Bacon King
  - BBQ Bacon King
  - Double Bacon Cheeseburger
  - Double Cheeseburger
  - Double Quarter Pound King
  - Extra Long Cheeseburger
  - Farmhouse King
  - Homestyle Cheeseburger
  - Jalapeno King Sandwich
  - Mushroom & Swiss King
  - Rodeo King
  - Sourdough King Single
  - Sourdough King Double
  - Steakhouse King
  - Bacon & Cheese Whopper
  - DOUBLE WHOPPER w/o Cheese
  - DOUBLE WHOPPER w/ Cheese
  - WHOPPER w/o Cheese
  - WHOPPER w/ Cheese
  - WHOPPER JR. w/ Cheese
  - Chicken BLT Salad w/ Crispy Chicken
  - Bacon Cheddar Ranch Crispy Chicken Sandwich
  - Chicken Fries
  - Crispy Buffalo Chicken Melt
  - Crispy Chicken Sandwich
  - Grilled Chili Cheese Dog
  - Grilled Hot Dog
  - Original Chicken Sandwich
  - Sourdough Chicken Club
  - 1/4 lb. Mushroom Swiss GrillBurger
  - 4 Piece Chicken Strip Basket w/ Country Gravy
  - 6 Piece Chicken Strip Basket w/ Country Gravy
  - Bacon Cheese Dog
  - Cheese Dog
  - Chili Dog
  - Hot Dog
  - Relish Dog
  - Large Cheese Curds
  - Chili Cheese Mega Dog
  - Steak Finger Basket
  - 1/2 lb.* Cheesy Potato Burrito
  - 1/2 lb.* Combo Burrito
  - Chili Cheese Burrito
  - Steak Quesarito
  - Beef Quesarito
  - Smothered Burrito - Beef
  - Smothered Burrito - Steak
  - XXL Grilled Stuft Burrito - Beef
  - XXL Grilled Stuft Burrito - Steak
  - Cheesy Gordita Crunch
  - Doritos® Cheesy Gordita Crunch - Cool Ranch
  - Doritos® Cheesy Gordita Crunch - Fiery
  - Doritos® Cheesy Gordita Crunch - Nacho Cheese
  - Cheese Quesadilla
  - Chicken Quesadilla
  - Express Taco Salad w/ Chips
  - Mexican Pizza
  - MexiMelt®
  - Steak Quesadilla
  - Fiesta Taco Salad-Beef
  - Fiesta Taco Salad-Steak
```

```python
# Calculate the metrics
homogeneity = metrics.homogeneity_score(ff_df['trans_fat'], 
ff_df['cluster'])
completeness = metrics.completeness_score(ff_df['trans_fat'], 
ff_df['cluster'])
v_measure = metrics.v_measure_score(ff_df['trans_fat'], 
ff_df['cluster'])
adjusted_rand = metrics.adjusted_rand_score(ff_df['trans_fat'], 
ff_df['cluster'])
adjusted_mutual_info = 
metrics.adjusted_mutual_info_score(ff_df['trans_fat'], 
ff_df['cluster'])
silhouette = metrics.silhouette_score(ff_df_processed, 
ff_df['cluster'])

# Display the metrics
print(f"Homogeneity Score: {homogeneity}")
print(f"Completeness Score: {completeness}")
print(f"V-Measure Score: {v_measure}")
print(f"Adjusted Rand Index: {adjusted_rand}")
print(f"Adjusted Mutual Information Score: {adjusted_mutual_info}")
print(f"Silhouette Score: {silhouette}")
```

```
Homogeneity Score: 0.5224492314339874
Completeness Score: 0.46665970888959185
V-Measure Score: 0.49298109907047516
Adjusted Rand Index: 0.4295936956509919
Adjusted Mutual Information Score: 0.48145706706902364
Silhouette Score: 0.3213769735272435
```

ANALYSIS OF CLUSTERING SOLUTION

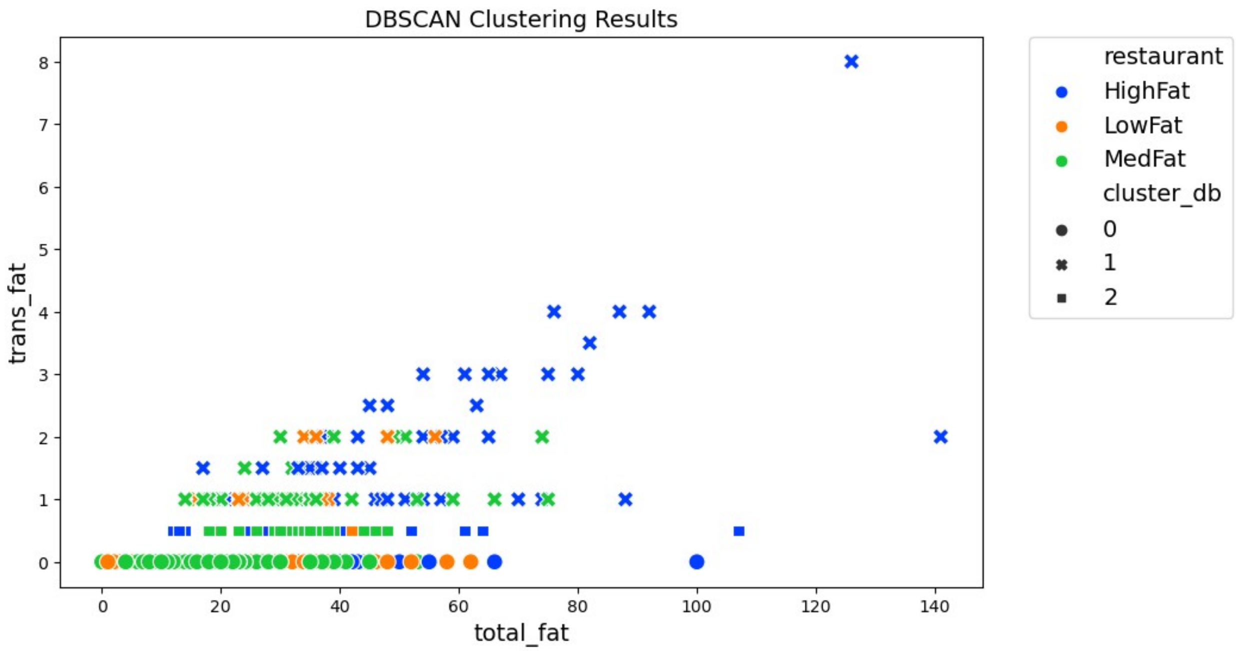
Based on the metrics, the K-Means clustering solution provides a reasonable balance between cluster homogeneity and completeness.

The clustering solution effectively groups similar items together, as evidenced by the silhouette score.

The clusters provide meaningful insights into the categorization of food items based on their trans_fat content, helping to identify patterns and relationships within the dataset.

2. DBSCAN MODEL

```
# Build a dbscan model on the ff_df_processed dataset with columns
Calories and Trans Fat
dbscan = DBSCAN(eps=0.18, min_samples=5)
ff_df['cluster_db'] = dbscan.fit_predict(ff_df_processed[['total_fat',
'trans_fat']])

plt.figure(figsize=(10, 6))
sns.scatterplot(x='total_fat', y='trans_fat', hue='restaurant',
style='cluster_db', palette='bright', data=ff_df, s=100)
plt.title('DBSCAN Clustering Results')
plt.xlabel('total_fat')
plt.ylabel('trans_fat')
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.show()
```



INTERPRETATION

Cluster 0: Total fat content between 0 and 100 while trans_fat is 0. Majority of Restaurants that have been classified as LowFat & MedFat food items seller fall under this category

Cluster 1: Total fat content between 17 and 140 while trans_fat ranges from 1 to 8. Majority of Restaurants that have been classified as HighFat food items seller and few of MedFat food items sellers fall under this category

Cluster 2: Total fat content between 10 and 110 while trans_fat is just 0.5. Majority of Restaurants that have been classified as MedFat food items seller & few of HighFat food items seller fall under this category

```
# Calculate the metrics
homogeneity = metrics.homogeneity_score(ff_df['trans_fat'],
ff_df['cluster_db'])
completeness = metrics.completeness_score(ff_df['trans_fat'],
ff_df['cluster_db'])
v_measure = metrics.v_measure_score(ff_df['trans_fat'],
ff_df['cluster_db'])
adjusted_rand = metrics.adjusted_rand_score(ff_df['trans_fat'],
ff_df['cluster_db'])
adjusted_mutual_info =
metrics.adjusted_mutual_info_score(ff_df['trans_fat'],
ff_df['cluster_db'])
silhouette = metrics.silhouette_score(ff_df_processed,
ff_df['cluster_db'])

# Display the metrics
print(f"Homogeneity Score: {homogeneity}")
print(f"Completeness Score: {completeness}")
print(f"V-Measure Score: {v_measure}")
print(f"Adjusted Rand Index: {adjusted_rand}")
print(f"Adjusted Mutual Information Score: {adjusted_mutual_info}")
print(f"Silhouette Score: {silhouette}")
```

```
Homogeneity Score: 0.7042992365102371
Completeness Score: 1.0000000000000002
V-Measure Score: 0.8264971566288754
Adjusted Rand Index: 0.9097253119777551
Adjusted Mutual Information Score: 0.8233610600510542
Silhouette Score: 0.1046594285286688
```

ANALYSIS OF CLUSTERING SOLUTION

Provides a high homogeneity and completeness score, indicating that the clusters are well-formed.

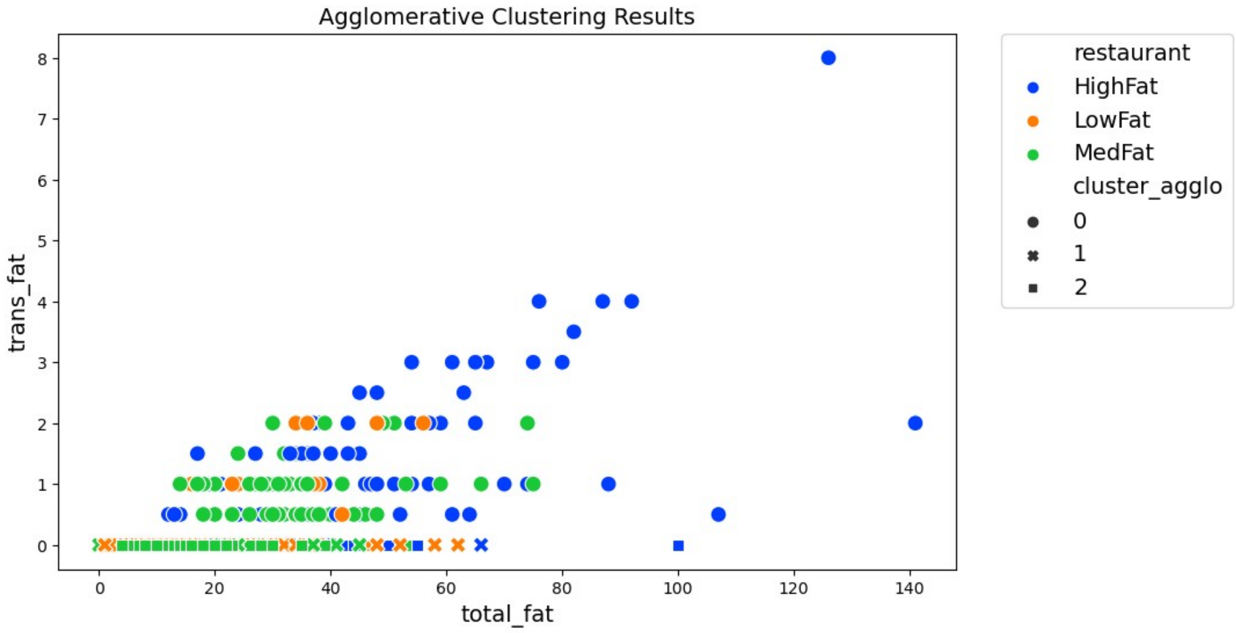
The high Adjusted Rand Index and Adjusted Mutual Information Score show strong similarity and agreement with the true labels.

However, the low silhouette score suggests that the clusters might not be very well-separated.

Despite the low silhouette score, DBSCAN effectively identifies outliers and forms clusters based on density, which can be more appropriate for non-linear data structures.

3. AGGLOMERATIVE MODEL

```
from sklearn.cluster import AgglomerativeClustering
from scipy.cluster.hierarchy import dendrogram, linkage

# Build an agglomerative clustering model on the ff_df_processed
dataset
agglo = AgglomerativeClustering(n_clusters=3)
ff_df['cluster_agglo'] = agglo.fit_predict(ff_df_processed)


# Plot the clustering results
plt.figure(figsize=(10, 6))
sns.scatterplot(x='total_fat', y='trans_fat', hue='restaurant',
style='cluster_agglo', data=ff_df, palette='bright', s=100)
plt.title('Agglomerative Clustering Results')
plt.xlabel('total_fat')
plt.ylabel('trans_fat')
plt.legend(bbox_to_anchor=(1.05, 1), loc=2, borderaxespad=0.)
plt.show()
```



INTERPRETATION

Cluster 0: Total fat content between 10 and 140 while trans_fat ranges from 0.5 to 8. Majority of Restaurants that have been classified as HighFat & MedFat food items seller fall under this category

Cluster 1: Total fat content between 0 and 70 while trans_fat is just 0. Restaurants that have been classified as LowFat food items seller few of MedFat food items sellers fall under this category

Cluster 2: Total fat content between 5 and 55 while trans_fat is just 0. Majority of Restaurants that have been classified as MedFat food items seller fall under this category

```
# Calculate the metrics
homogeneity = metrics.homogeneity_score(ff_df['trans_fat'],
ff_df['cluster_agglo'])
completeness = metrics.completeness_score(ff_df['trans_fat'],
ff_df['cluster_agglo'])
v_measure = metrics.v_measure_score(ff_df['trans_fat'],
ff_df['cluster_agglo'])
adjusted_rand = metrics.adjusted_rand_score(ff_df['trans_fat'],
ff_df['cluster_agglo'])
adjusted_mutual_info =
metrics.adjusted_mutual_info_score(ff_df['trans_fat'],
ff_df['cluster_agglo'])
silhouette = metrics.silhouette_score(ff_df_processed[['calories',
'trans_fat']], ff_df['cluster_agglo'])

# Display the metrics
print(f"Homogeneity Score: {homogeneity}")
print(f"Completeness Score: {completeness}")
print(f"V-Measure Score: {v_measure}")
print(f"Adjusted Rand Index: {adjusted_rand}")
print(f"Adjusted Mutual Information Score: {adjusted_mutual_info}")
print(f"Silhouette Score: {silhouette}")
```

```
Homogeneity Score: 0.5457358466545749
Completeness Score: 0.5965430377702181
V-Measure Score: 0.5700095208314364
Adjusted Rand Index: 0.39856329931995726
Adjusted Mutual Information Score: 0.5625346968988931
Silhouette Score: 0.285187376261715
```

ANALYSIS OF CLUSTERING SOLUTION

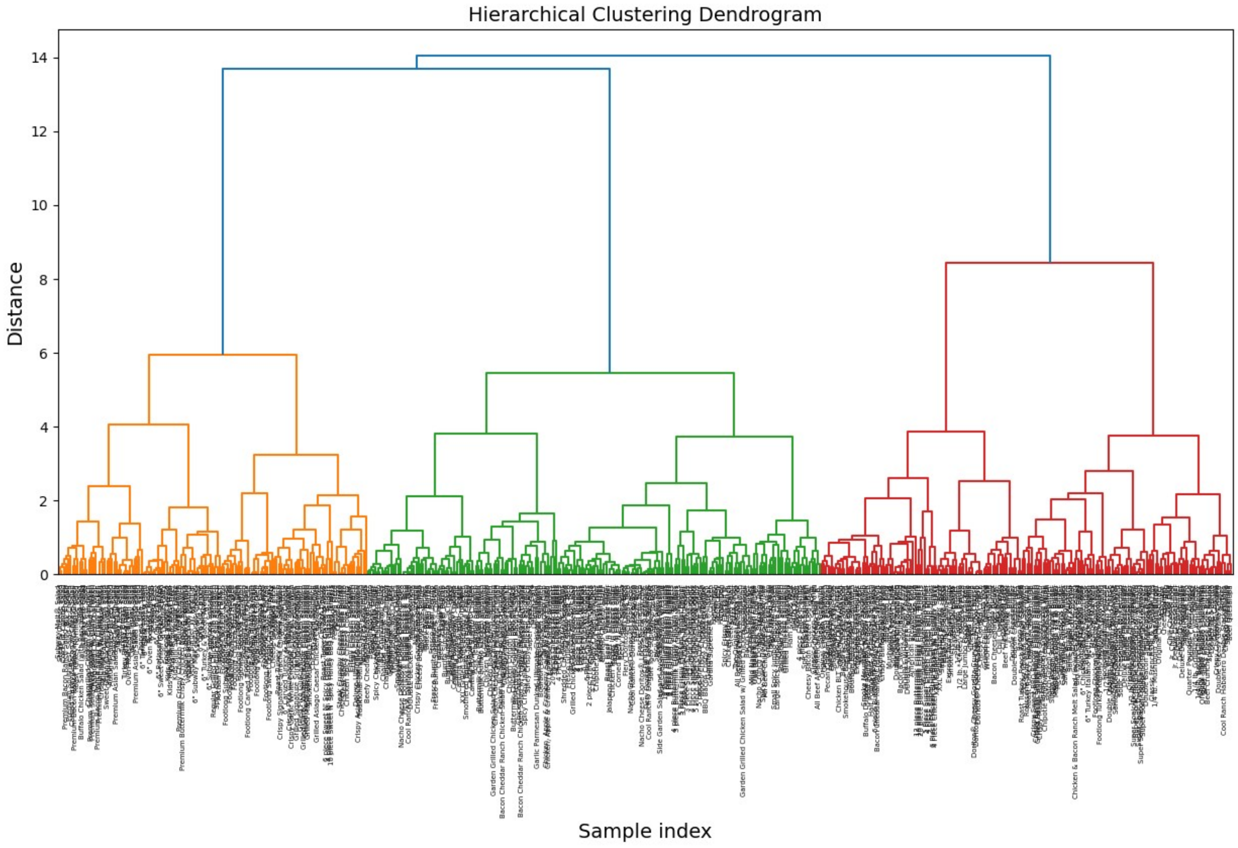
Provides moderate homogeneity and completeness scores, indicating a fair formation of clusters.

The moderate Adjusted Rand Index and Adjusted Mutual Information Score show a decent similarity and agreement with the true labels.

The silhouette score suggests that the clusters have a fair density and separation.

This method can effectively identify the hierarchical structure within the data, making it suitable for datasets with nested clusters.

```python
# Create dendrogram
linked = linkage(ff_df_processed, method='ward')
plt.figure(figsize=(15, 7))
dendrogram(linked, orientation='top', labels=ff_df['item'].to_numpy(),
distance_sort='descending', show_leaf_counts=True)
plt.title('Hierarchical Clustering Dendrogram')
plt.xlabel('Sample index')
plt.ylabel('Distance')
plt.show()
```



BEST CLUSTERING TECHNIQUE

DBSCAN Clustering emerges as the best technique for this dataset

JUSTIFICATION

High Homogeneity and Completeness Scores: Indicates well-formed clusters.

High Adjusted Rand Index and Adjusted Mutual Information Score: Shows strong similarity with true labels.

Outlier Identification: DBSCAN effectively identifies outliers, which is beneficial for datasets with noise.

Density-Based Clustering: Suitable for non-linear data structures and discovering clusters of varying shapes and sizes.

Despite the low silhouette score, which suggests possible issues with cluster separation, the overall performance and characteristics of DBSCAN make it the most suitable choice for this particular dataset and clustering task.