

```
In [59]: %time
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import sklearn as sk
from sklearn.decomposition import PCA
from sklearn.cluster import KMeans, DBSCAN
from scipy.stats import zscore
import scipy.cluster.hierarchy as ch
from sklearn.cluster import AgglomerativeClustering
from sklearn.preprocessing import LabelEncoder
pd.options.display.max_columns = None
```

CPU times: user 2 μ s, sys: 0 ns, total: 2 μ s

Wall time: 4.05 μ s

```
In [60]: df = pd.read_csv("../data_cleaned/cleaned_dataset_no_zeros.csv")
df.head(20)
```

```
Out[60]:
```

	Species	Country.of.Origin	Variety	Processing.Method	Aroma	Flavor	Aftertaste
0	Arabica	Ethiopia	Caturra	Washed / Wet	8.67	8.83	8.67
1	Arabica	Ethiopia	Other	Washed / Wet	8.75	8.67	8.50
2	Arabica	Guatemala	Bourbon	Washed / Wet	8.42	8.50	8.42
3	Arabica	Ethiopia	Caturra	Natural / Dry	8.17	8.58	8.42
4	Arabica	Ethiopia	Other	Washed / Wet	8.25	8.50	8.25
5	Arabica	Ethiopia	Caturra	Washed / Wet	8.25	8.33	8.50
6	Arabica	Ethiopia	Caturra	Washed / Wet	8.67	8.67	8.58
7	Arabica	Ethiopia	Other	Natural / Dry	8.08	8.58	8.50
8	Arabica	Ethiopia	Caturra	Natural / Dry	8.17	8.67	8.25
9	Arabica	United States	Other	Washed / Wet	8.25	8.42	8.17
10	Arabica	United States	Other	Washed / Wet	8.08	8.67	8.33
11	Arabica	United States (Hawaii)	Caturra	Washed / Wet	8.33	8.42	8.08
12	Arabica	Ethiopia	Caturra	Washed / Wet	8.25	8.33	8.50
13	Arabica	United States	Other	Washed / Wet	8.00	8.50	8.58
14	Arabica	Indonesia	Caturra	Washed / Wet	8.33	8.25	7.83
15	Arabica	China	Catimor	Washed / Wet	8.42	8.25	8.08
16	Arabica	Ethiopia	Ethiopian Yirgacheffe	Natural / Dry	8.17	8.17	8.00
17	Arabica	United States	Other	Washed / Wet	8.00	8.25	8.08
18	Arabica	Costa Rica	Caturra	Washed / Wet	8.08	8.25	8.00
19	Arabica	Mexico	Other	Washed / Wet	8.17	8.25	8.17

```
In [61]: df.columns
```

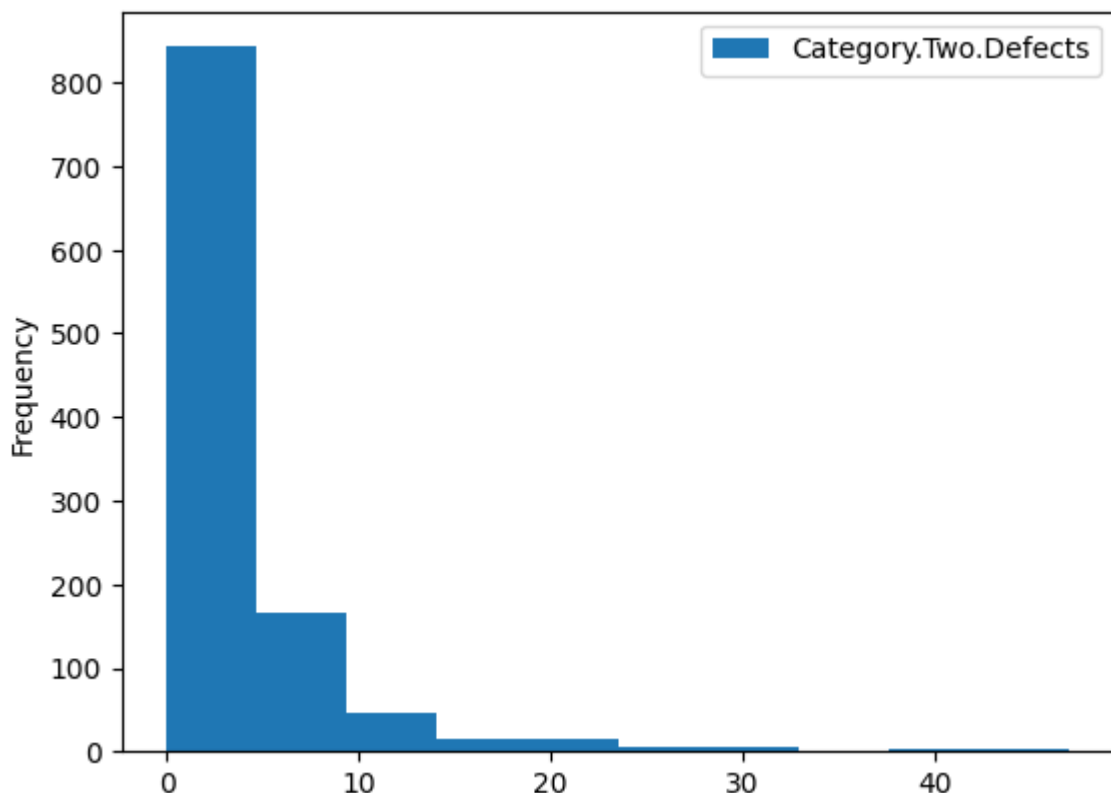
```
Out[61]: Index(['Species', 'Country.of.Origin', 'Variety', 'Processing.Method',
               'Aroma',
               'Flavor', 'Aftertaste', 'Acidity', 'Body', 'Balance', 'Uniformity',
               'Clean.Cup', 'Sweetness', 'Cupper.Points', 'Total.Cup.Points',
               'Moisture', 'Category.One.Defects', 'Quakers', 'Color',
               'Category.Two.Defects', 'altitude_mean_meters'],
              dtype='object')
```

```
In [62]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 1103 entries, 0 to 1102  
Data columns (total 21 columns):  
#   Column                                Non-Null Count  Dtype    
---  -  
0   Species                               1103 non-null   object   
1   Country.of.Origin                     1103 non-null   object   
2   Variety                                1103 non-null   object   
3   Processing.Method                      1103 non-null   object   
4   Aroma                                  1103 non-null   float64  
5   Flavor                                 1103 non-null   float64  
6   Aftertaste                             1103 non-null   float64  
7   Acidity                                1103 non-null   float64  
8   Body                                    1103 non-null   float64  
9   Balance                                1103 non-null   float64  
10  Uniformity                             1103 non-null   float64  
11  Clean.Cup                              1103 non-null   float64  
12  Sweetness                              1103 non-null   float64  
13  Cupper.Points                          1103 non-null   float64  
14  Total.Cup.Points                       1103 non-null   float64  
15  Moisture                               1103 non-null   float64  
16  Category.One.Defects                   1103 non-null   int64    
17  Quakers                                1103 non-null   float64  
18  Color                                  1103 non-null   object   
19  Category.Two.Defects                   1103 non-null   int64    
20  altitude_mean_meters                   1103 non-null   float64  
dtypes: float64(14), int64(2), object(5)  
memory usage: 181.1+ KB
```

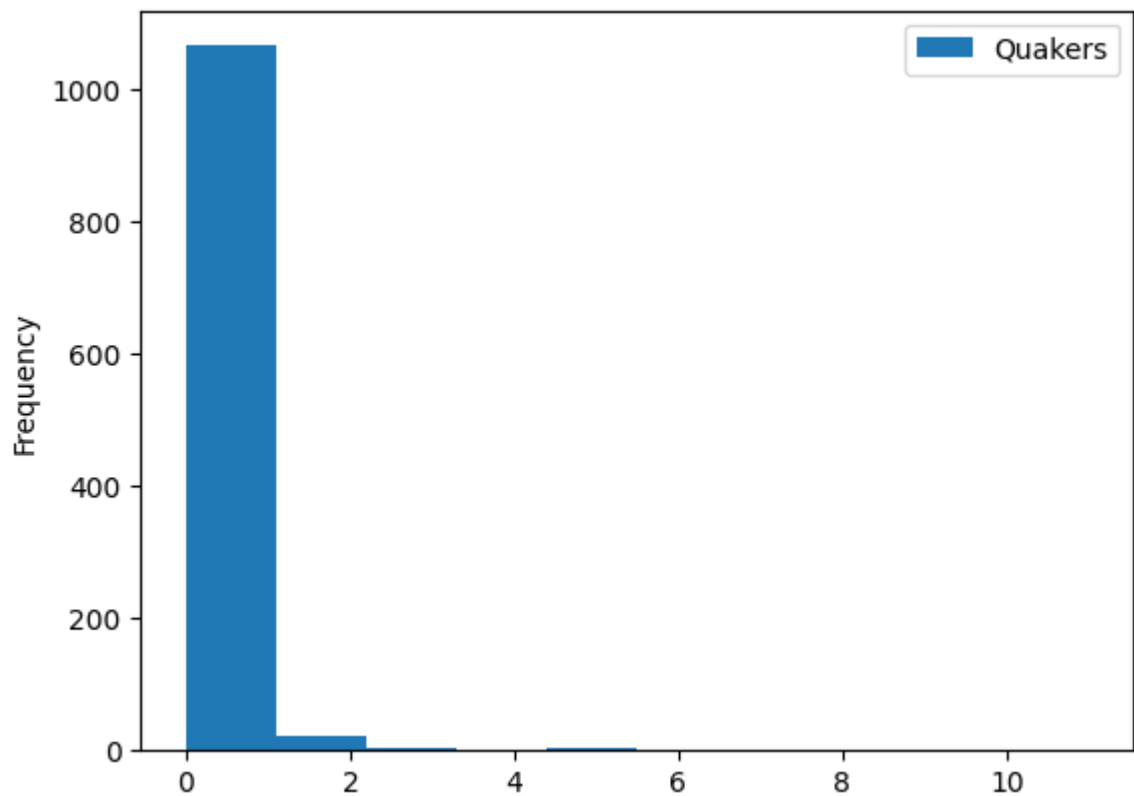
```
In [67]: df[['Category.Two.Defects']].plot.hist()
```

```
Out[67]: <Axes: ylabel='Frequency'>
```



```
In [68]: # we're gonna keep these outlying values, as they might have a high impac  
df[['Quakers']].plot.hist()
```

Out[68]: <Axes: ylabel='Frequency'>



Data Exploration

```
In [69]: # lets see which countries can boast the highest cup grades
df.groupby('Country.of.Origin')['Total.Cup.Points'].mean().reset_index().
```

Out [69] :

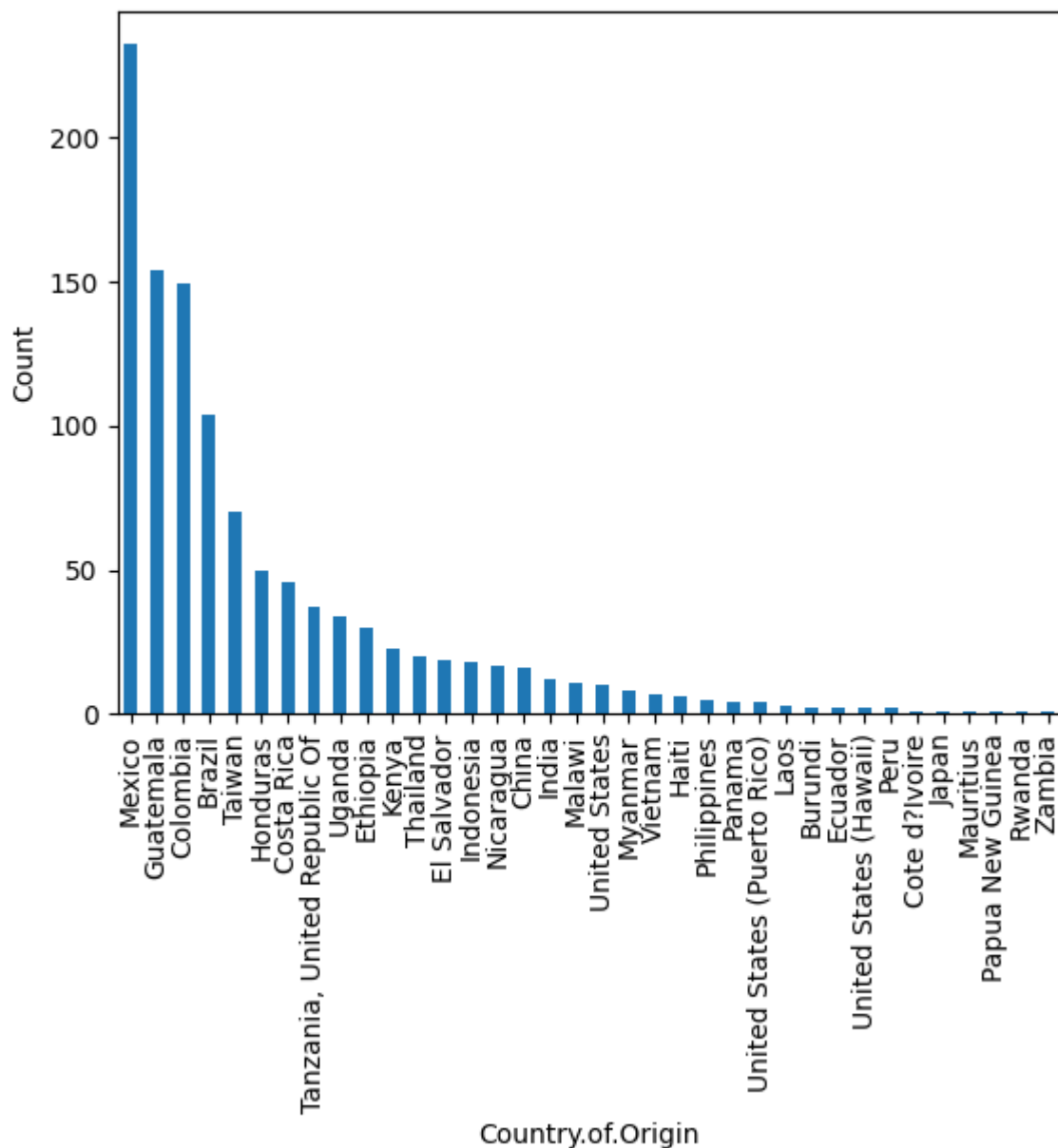
	Country.of.Origin	Total.Cup.Points
32	United States (Hawaii)	86.960000
8	Ethiopia	85.916333
23	Papua New Guinea	85.750000
14	Japan	84.670000
31	United States	84.433000
15	Kenya	84.271304
22	Panama	83.707500
30	Uganda	83.382941
3	Colombia	83.224832
7	El Salvador	83.115263
2	China	82.927500
26	Rwanda	82.830000
4	Costa Rica	82.800435
0	Brazil	82.711442
13	Indonesia	82.528333
29	Thailand	82.430000
28	Tanzania, United Republic Of	82.309459
34	Vietnam	82.274286
9	Guatemala	82.024221
27	Taiwan	81.947714
12	India	81.937500
35	Zambia	81.920000
16	Laos	81.833333
1	Burundi	81.830000
33	United States (Puerto Rico)	81.727500
17	Malawi	81.711818
6	Ecuador	80.955000
19	Mexico	80.863060
25	Philippines	80.834000
11	Honduras	80.832200
20	Myanmar	80.750000
18	Mauritius	80.500000
21	Nicaragua	80.010000

	Country.of.Origin	Total.Cup.Points
5	Cote d'Ivoire	79.330000
24	Peru	78.000000
10	Haiti	77.180000

Seems like a mixed bag from around the world. Quality doesn't seem to be linked regionally, but there is a small majority of african countries in the top half, and Hawaiian coffee seems to be a specialty!

```
In [70]: df.groupby('Country.of.Origin').size().sort_values(ascending=False).plot.
```

```
Out[70]: <Axes: xlabel='Country.of.Origin', ylabel='Count'>
```



Though we see that there is a very skewed representation of countries in the dataset. About 1/4 of the coffee in the dataset is from Mexico!

```
In [71]: df.groupby('Country.of.Origin')['Total.Cup.Points'].median().reset_index()
```

Out[71]:

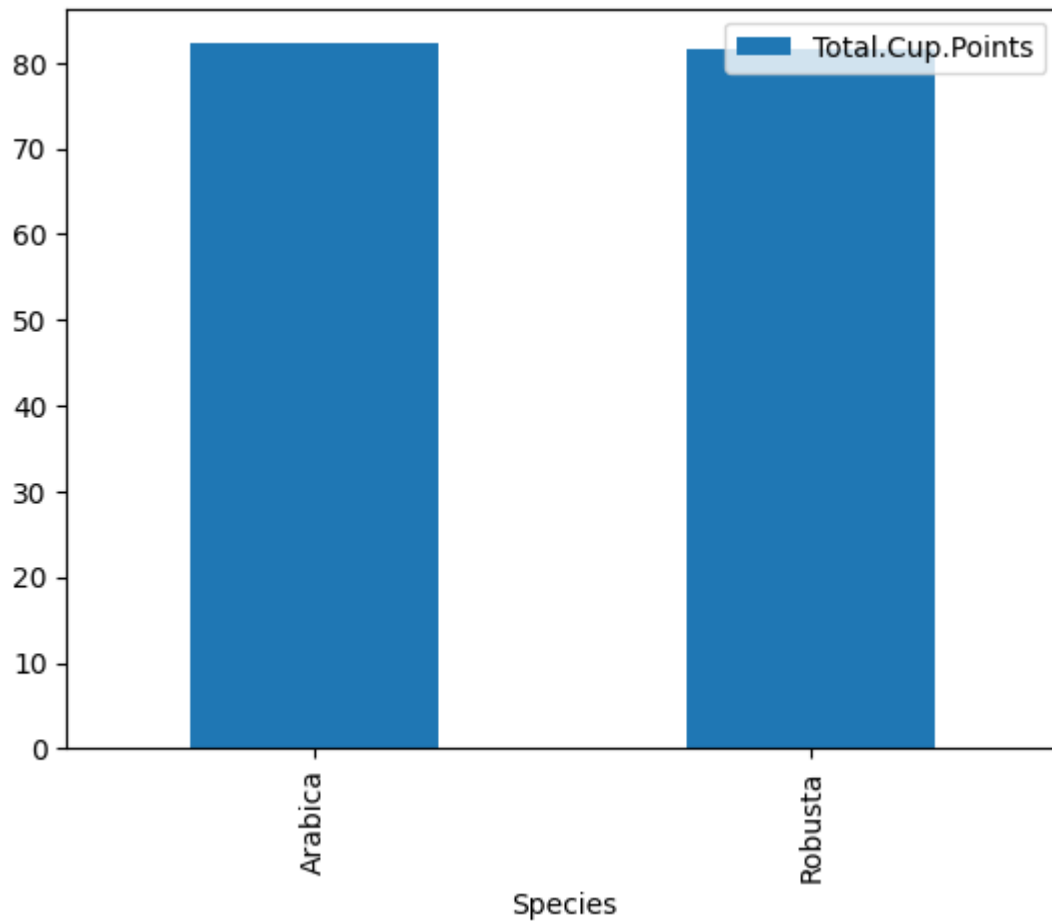
	Country.of.Origin	Total.Cup.Points
32	United States (Hawaii)	86.960
31	United States	86.625
23	Papua New Guinea	85.750
8	Ethiopia	85.250
14	Japan	84.670
15	Kenya	84.580
22	Panama	84.125
3	Colombia	83.250
2	China	83.170
4	Costa Rica	83.165
30	Uganda	83.085
7	El Salvador	82.920
34	Vietnam	82.830
26	Rwanda	82.830
13	Indonesia	82.665
29	Thailand	82.540
9	Guatemala	82.540
0	Brazil	82.500
28	Tanzania, United Republic Of	82.170
12	India	82.040
33	United States (Puerto Rico)	82.040
16	Laos	82.000
35	Zambia	81.920
27	Taiwan	81.875
1	Burundi	81.830
11	Honduras	81.625
17	Malawi	81.580
19	Mexico	81.580
25	Philippines	81.330
6	Ecuador	80.955
21	Nicaragua	80.920
20	Myanmar	80.625
18	Mauritius	80.500

	Country.of.Origin	Total.Cup.Points
5	Cote d'Ivoire	79.330
10	Haiti	79.000
24	Peru	78.000

Taking the median values, it seems about the same

```
In [72]: df.groupby('Species')['Total.Cup.Points'].mean().reset_index().sort_value
```

```
Out[72]: <Axes: xlabel='Species'>
```



Surprisingly, The Robusta species does not seem to have a much lower average score than Arabica, which we thought were far superior in taste

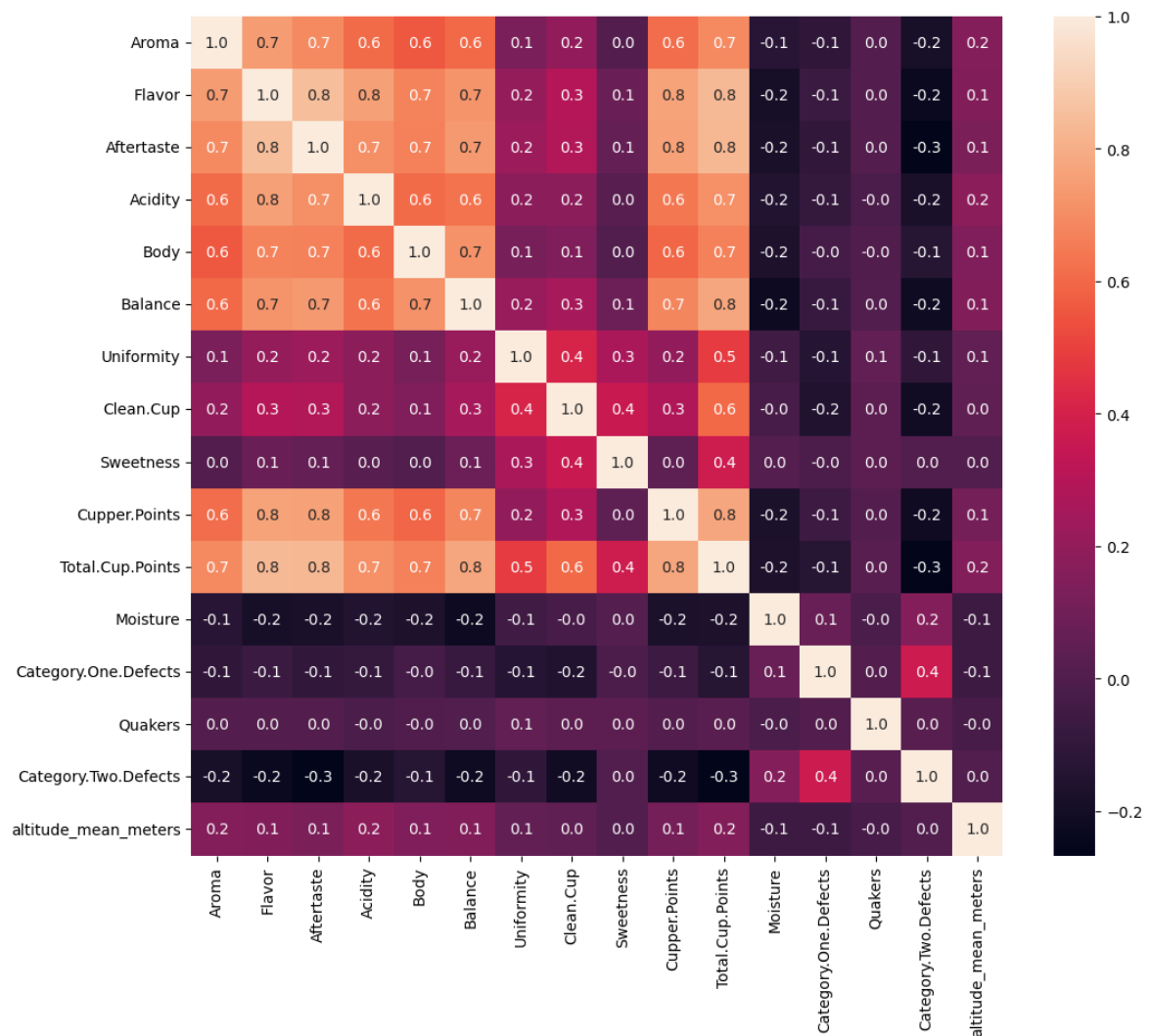
```
In [73]: corr_mat = df.corr(numeric_only=True)
corr_mat
```


Out[73]:

	Aroma	Flavor	Aftertaste	Acidity	Body	Balan
Aroma	1.000000	0.743109	0.688130	0.606707	0.558217	0.602133
Flavor	0.743109	1.000000	0.849983	0.757027	0.668397	0.722149
Aftertaste	0.688130	0.849983	1.000000	0.705410	0.666111	0.737439
Acidity	0.606707	0.757027	0.705410	1.000000	0.604118	0.624788
Body	0.558217	0.668397	0.666111	0.604118	1.000000	0.715045
Balance	0.602133	0.722149	0.737439	0.624788	0.715045	1.000000
Uniformity	0.126962	0.207079	0.226183	0.178229	0.116480	0.215430
Clean.Cup	0.196811	0.297936	0.288698	0.176823	0.140021	0.254270
Sweetness	0.008310	0.077417	0.063372	0.022285	0.002498	0.083590
Cupper.Points	0.611088	0.764423	0.761057	0.642121	0.590999	0.679210
Total.Cup.Points	0.688725	0.836167	0.827814	0.708001	0.665436	0.775300
Moisture	-0.131316	-0.189600	-0.178685	-0.151101	-0.171327	-0.227080
Category.One.Defects	-0.104645	-0.069596	-0.103180	-0.090468	-0.035044	-0.079430
Quakers	0.007763	0.009010	0.007843	-0.017353	-0.002792	0.001000
Category.Two.Defects	-0.184304	-0.233813	-0.263210	-0.181162	-0.138092	-0.218800
altitude_mean_meters	0.155328	0.148021	0.133273	0.181499	0.142243	0.144400

```
In [74]: plt.figure(figsize=(12, 10))
sns.heatmap(corr_mat, annot = True, fmt = ".1f")
```

Out[74]: <Axes: >



Unsurprisingly the different flavor parameters seems to correlate a lot with the Total Cup Points, and with each other. It seems that the main parameters that drags down the score is the amount of Category One and Two Defects, which we also suspected. Quakers doesn't seem to have a big impact on the overall Cup Point score. This might, of course, be biased by the low amount of values above zero

```
In [75]: df.dtypes
```

```
Out[75]: Species                object
Country.of.Origin             object
Variety                       object
Processing.Method              object
Aroma                         float64
Flavor                        float64
Aftertaste                    float64
Acidity                       float64
Body                          float64
Balance                       float64
Uniformity                    float64
Clean.Cup                     float64
Sweetness                     float64
Cupper.Points                 float64
Total.Cup.Points              float64
Moisture                      float64
Category.One.Defects           int64
Quakers                      float64
Color                         object
Category.Two.Defects           int64
altitude_mean_meters          float64
dtype: object
```

Lets label encode the categorical data, so we can see how the nominal data affects the correlation score as well

```
In [76]: le = LabelEncoder()
cols_to_enc = df.select_dtypes(include='object').columns
enc_df = df.copy()

for col in cols_to_enc:
    enc_df[col] = le.fit_transform(df[col]).astype(int)

enc_df
```

```
Out[76]:
```

	Species	Country.of.Origin	Variety	Processing.Method	Aroma	Flavor	Aftertaste
0	0	8	5	4	8.67	8.83	8.67
1	0	8	13	4	8.75	8.67	8.50
2	0	9	2	4	8.42	8.50	8.42
3	0	8	5	0	8.17	8.58	8.42
4	0	8	13	4	8.25	8.50	8.25
...
1098	1	12	5	4	7.67	7.67	7.50
1099	1	12	5	0	7.58	7.42	7.42
1100	1	31	0	0	7.92	7.50	7.42
1101	1	6	5	4	7.50	7.67	7.75
1102	1	31	5	0	7.33	7.33	7.17

1103 rows × 21 columns

```
In [77]: enc_df.to_csv("../data_cleaned/encoded_df.csv", index=False)
```

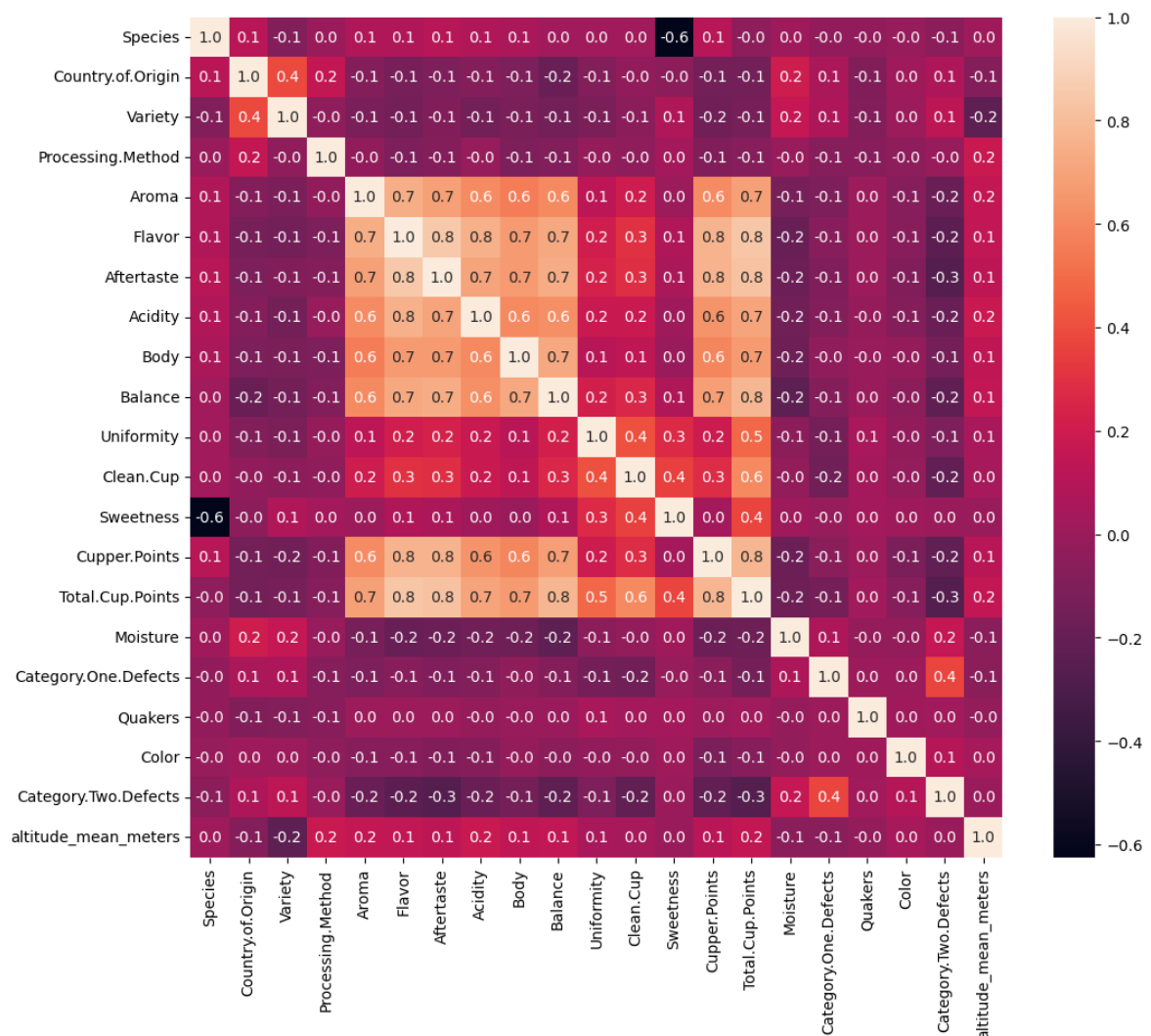
```
In [78]: # lets see how much variance it give us  
df.describe()
```

```
Out[78]:
```

	Aroma	Flavor	Aftertaste	Acidity	Body	Balance
count	1103.000000	1103.000000	1103.000000	1103.000000	1103.000000	1103.000000
mean	7.578368	7.527824	7.401496	7.535739	7.513654	7.512660
std	0.309181	0.331268	0.340065	0.313192	0.289467	0.354020
min	5.080000	6.170000	6.170000	5.250000	5.170000	5.250000
25%	7.420000	7.330000	7.250000	7.330000	7.330000	7.330000
50%	7.580000	7.580000	7.420000	7.500000	7.500000	7.500000
75%	7.750000	7.750000	7.580000	7.750000	7.670000	7.750000
max	8.750000	8.830000	8.670000	8.750000	8.580000	8.750000

```
In [79]: enc_corr_mat = enc_df.corr()  
plt.figure(figsize=(12, 10))  
sns.heatmap(enc_corr_mat, annot = True, fmt = ".1f")
```

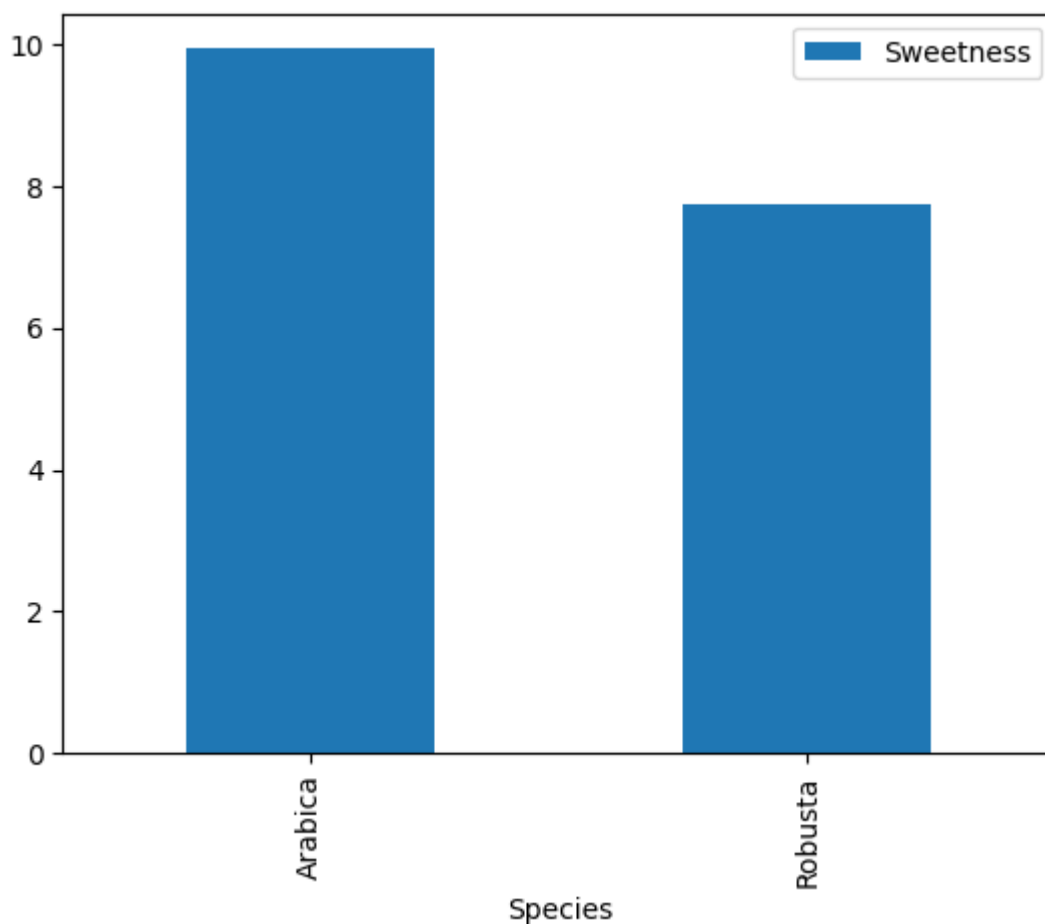
```
Out[79]: <Axes: >
```



The species of the coffee seems to have a significant impact on the sweetness

```
In [80]: # Sweetnes grouped by species  
df.groupby('Species')['Sweetness'].mean().reset_index().plot.bar(x='Speci
```

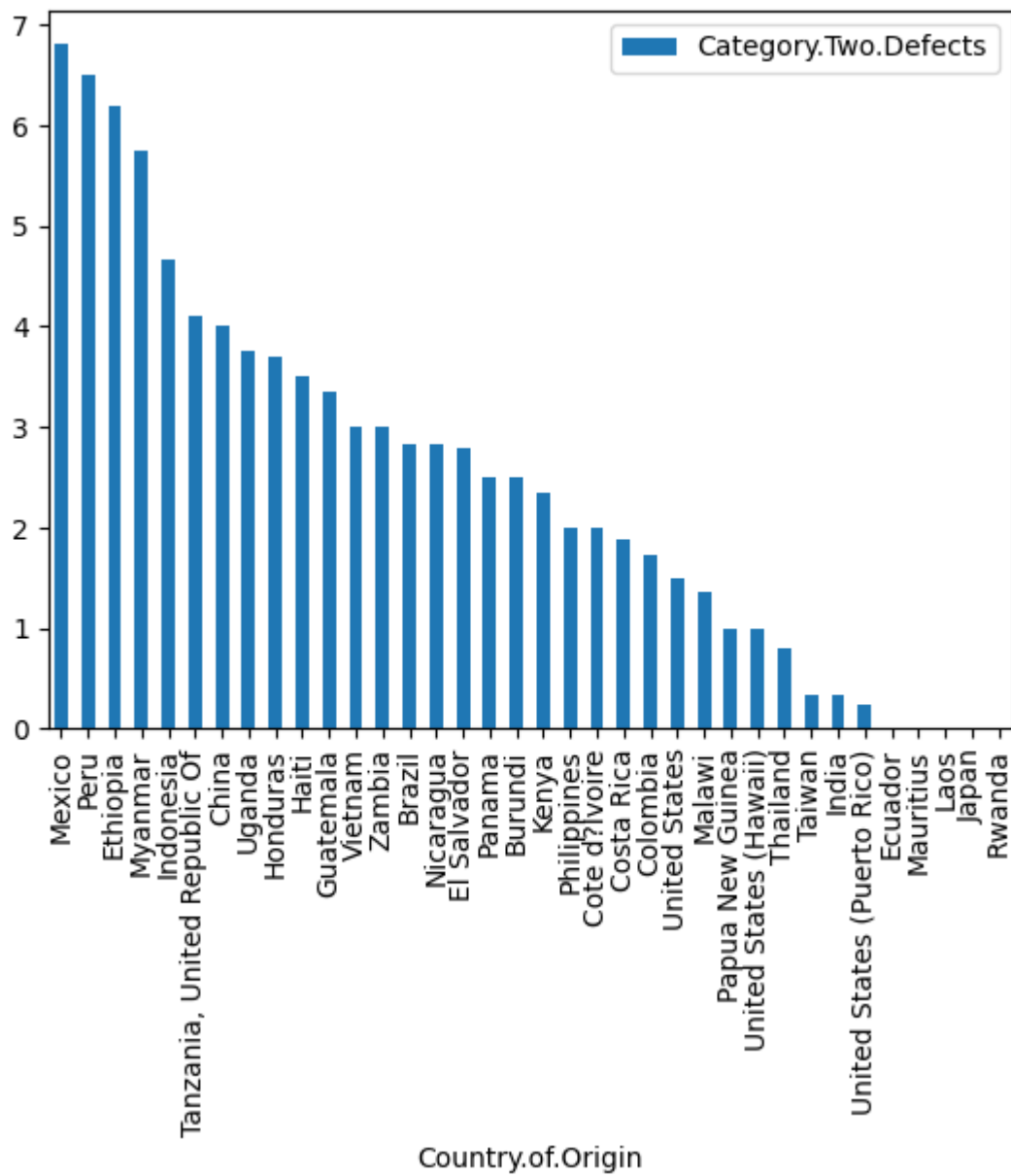
```
Out[80]: <Axes: xlabel='Species'>
```



So this is where the Arabica beans stand out!

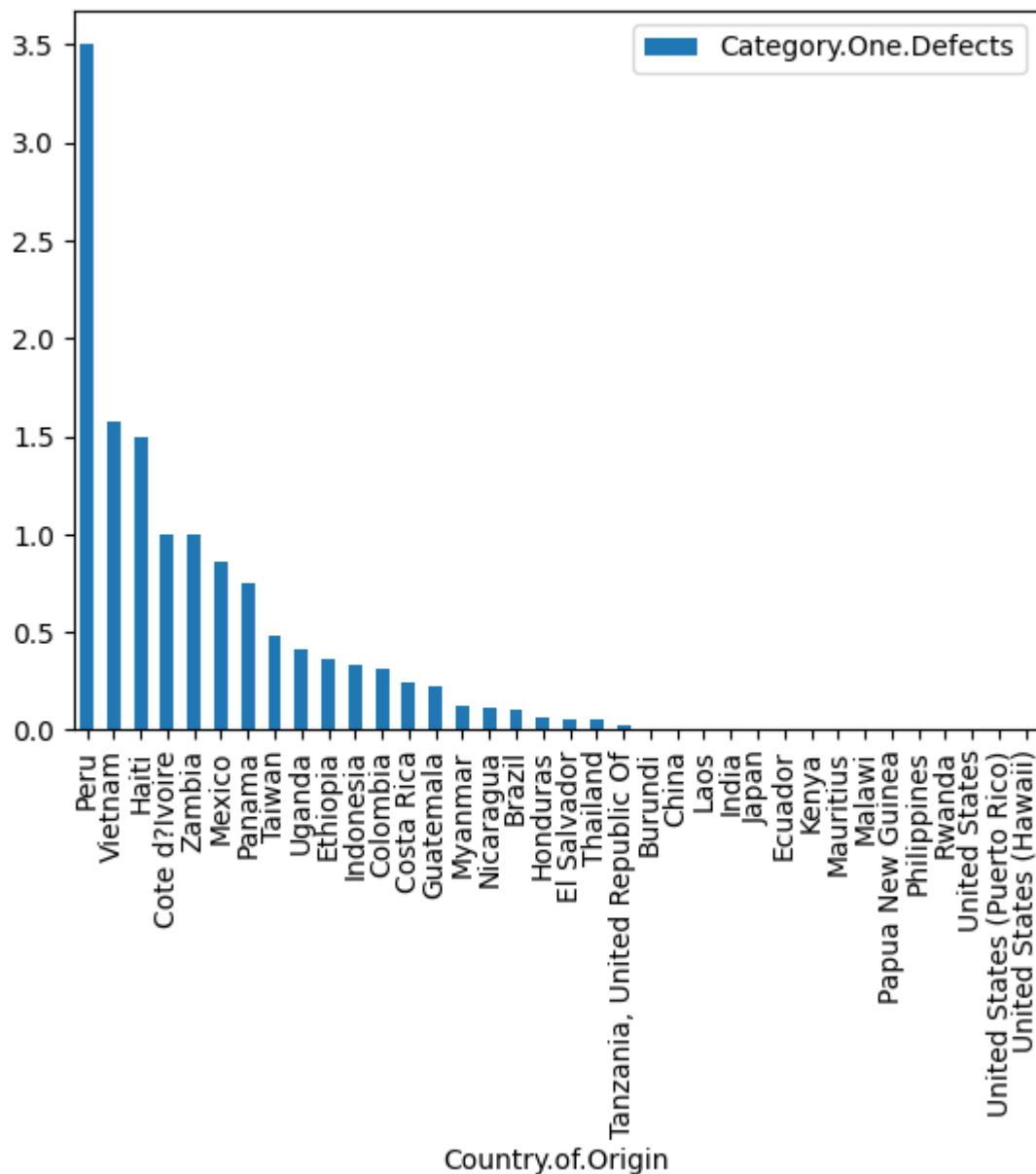
```
In [81]: df.groupby('Country.of.Origin')['Category.Two.Defects'].mean().reset_inde
```

```
Out[81]: <Axes: xlabel='Country.of.Origin'>
```



```
In [82]: df.groupby('Country.of.Origin')['Category.One.Defects'].mean().reset_index
```

```
Out[82]: <Axes: xlabel='Country.of.Origin'>
```



Interestingly though, we also find Ethiopia among the countries with the highest mean in Category 2 defect parameters, even though it is the country with the 4th averagely highest scoring coffee. This indicates that it takes rather large amounts of defects in the coffee to really make an impact on the overall score.

Clustering model training

We'll try to extract more information with clustering models. For this purpose we drop our previous target feature "Total Cup Points" and scale the feature values in the dataset, so we can do a principal component analysis

```
In [83]: # df_cls = enc_df.drop('Total Cup Points', axis=1)
df_cls = enc_df.copy()
```

```
In [84]: df_cls[df_cls.columns] = sk.preprocessing.StandardScaler().fit_transform(df_cls)
```

```
In [85]: df_cls.sample(5)
```

```
Out[85]:
```

	Species	Country.of.Origin	Variety	Processing.Method	Aroma	Flavor
962	-0.152286	-0.441966	-0.958392	0.526081	-0.253585	-1.594069
307	-0.152286	-1.070443	-0.620082	0.526081	-0.253585	0.157575
849	-0.152286	0.710241	0.282078	-1.445381	-1.321406	-0.325637
1002	-0.152286	0.605495	1.635319	0.526081	-0.803674	-1.594069
292	-0.152286	1.548210	0.845929	0.526081	0.555370	0.429382

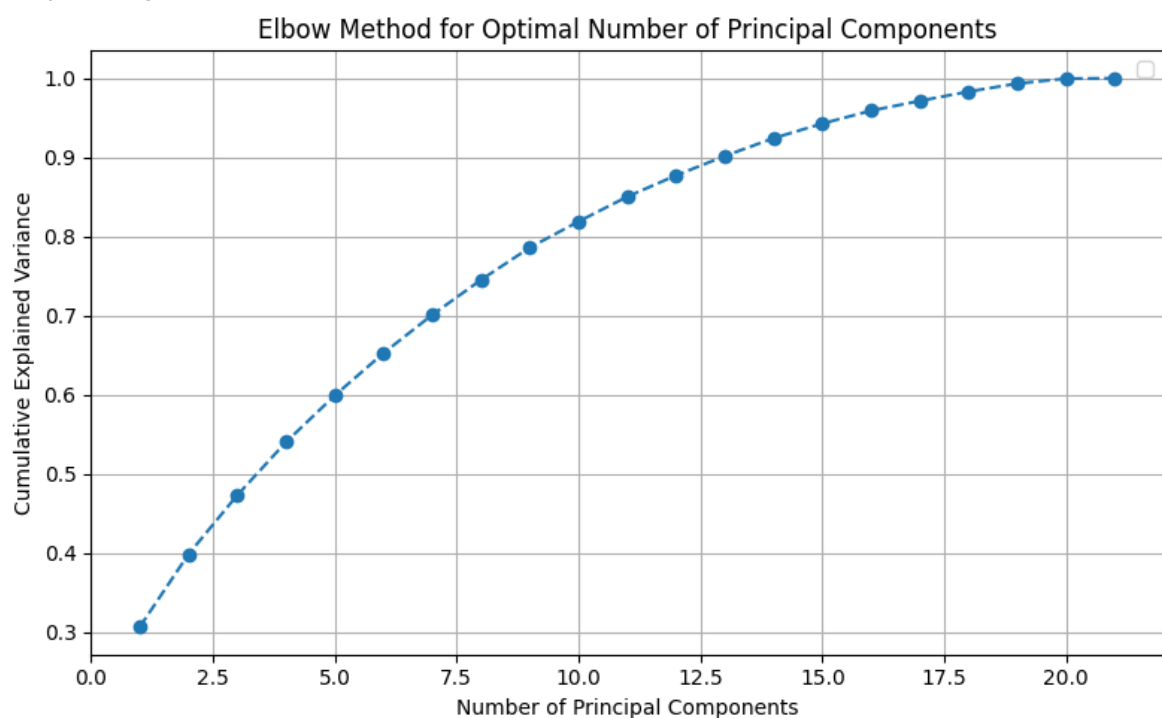
```
In [86]: pca = PCA()
pca.fit(df_cls)
explained_variance = pca.explained_variance_ratio_
cumulative_variance = np.cumsum(explained_variance)
# 3 principal components
cumulative_variance[2]
```

```
Out[86]: np.float64(0.4725891234734746)
```

```
In [87]: plt.figure(figsize=(8, 5))
plt.plot(range(1, len(cumulative_variance) + 1), cumulative_variance, mar
plt.xlabel('Number of Principal Components')
plt.ylabel('Cumulative Explained Variance')
plt.title('Elbow Method for Optimal Number of Principal Components')
plt.grid(True)
plt.legend()
plt.tight_layout()
plt.show()
```

/tmp/ipykernel_12403/3103998374.py:7: UserWarning: No artists with labels found to put in legend. Note that artists whose label start with an under score are ignored when legend() is called with no argument.

```
plt.legend()
```



Not as much as we hoped for. For 3 principal components, we get just above 50% explained variance, which is not a lot. Lets try and extract high correlating features and do

the PCA again

```
In [88]: df_cls_ext = enc_df[["Aroma", "Flavor", "Acidity", "Body", "Balance", "Afterta  
df_cls_ext[df_cls_ext.columns] = sk.preprocessing.StandardScaler().fit_tr
```

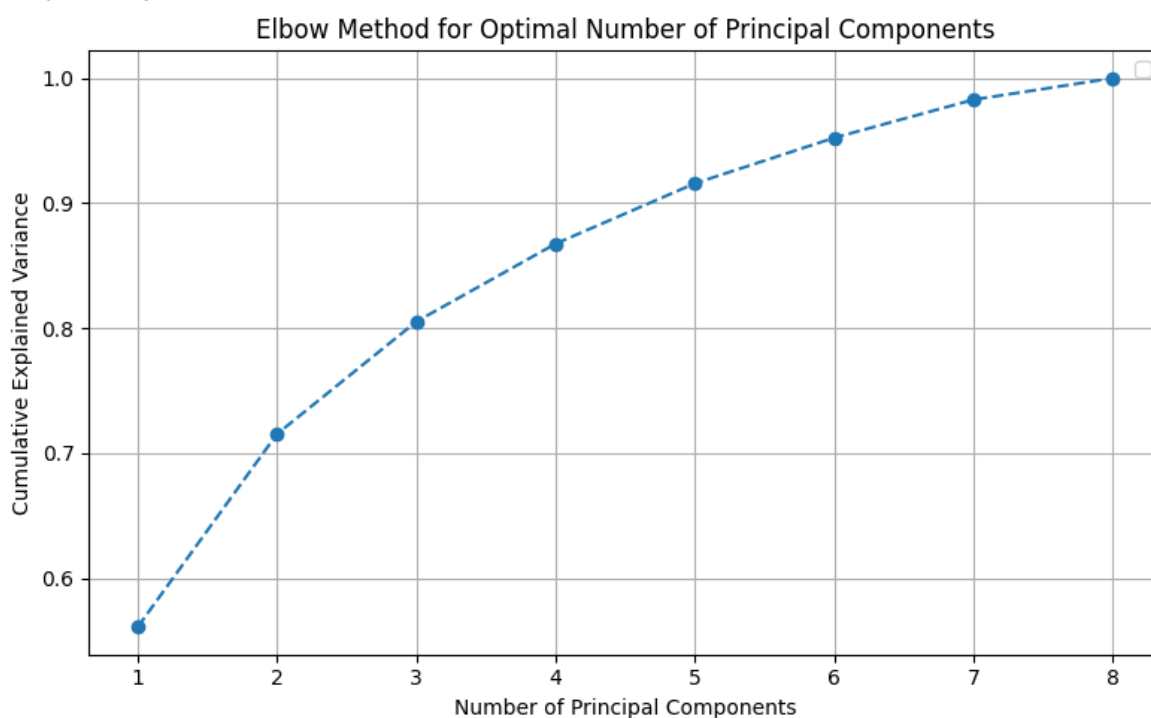
```
In [89]: pca = PCA()  
pca.fit(df_cls_ext)  
explained_variance = pca.explained_variance_ratio_  
cumulative_variance = np.cumsum(explained_variance)  
# 3 principal components  
cumulative_variance[2]
```

```
Out[89]: np.float64(0.8053004618615184)
```

```
In [90]: plt.figure(figsize=(8, 5))  
plt.plot(range(1, len(cumulative_variance) + 1), cumulative_variance, mar  
plt.xlabel('Number of Principal Components')  
plt.ylabel('Cumulative Explained Variance')  
plt.title('Elbow Method for Optimal Number of Principal Components')  
plt.grid(True)  
plt.legend()  
plt.tight_layout()  
plt.show()
```

/tmp/ipykernel_12403/3103998374.py:7: UserWarning: No artists with labels found to put in legend. Note that artists whose label start with an under score are ignored when legend() is called with no argument.

```
plt.legend()
```



Now we have an explained variance of above 70% with 2 principal components. Much better!

```
In [91]: pca_2 = PCA(n_components=2)  
pca_2_result = pca_2.fit_transform(df_cls_ext)  
dataset_pca = pd.DataFrame(abs(pca_2.components_), columns=df_cls_ext.col  
dataset_pca
```

```
Out[91]:
```

	Aroma	Flavor	Acidity	Body	Balance	Aftertaste	Uniformity	Sweetness
PC_1	0.381225	0.436044	0.392771	0.381476	0.404040	0.428197	0.128396	0.04
PC_2	0.103547	0.019839	0.057700	0.113975	0.009413	0.009358	0.659328	0.73

Here is our principal components. We see that PC1 is weighted across all the features, with a dive in Uniformity and Sweetness, while PC2 is mostly weighted by these.

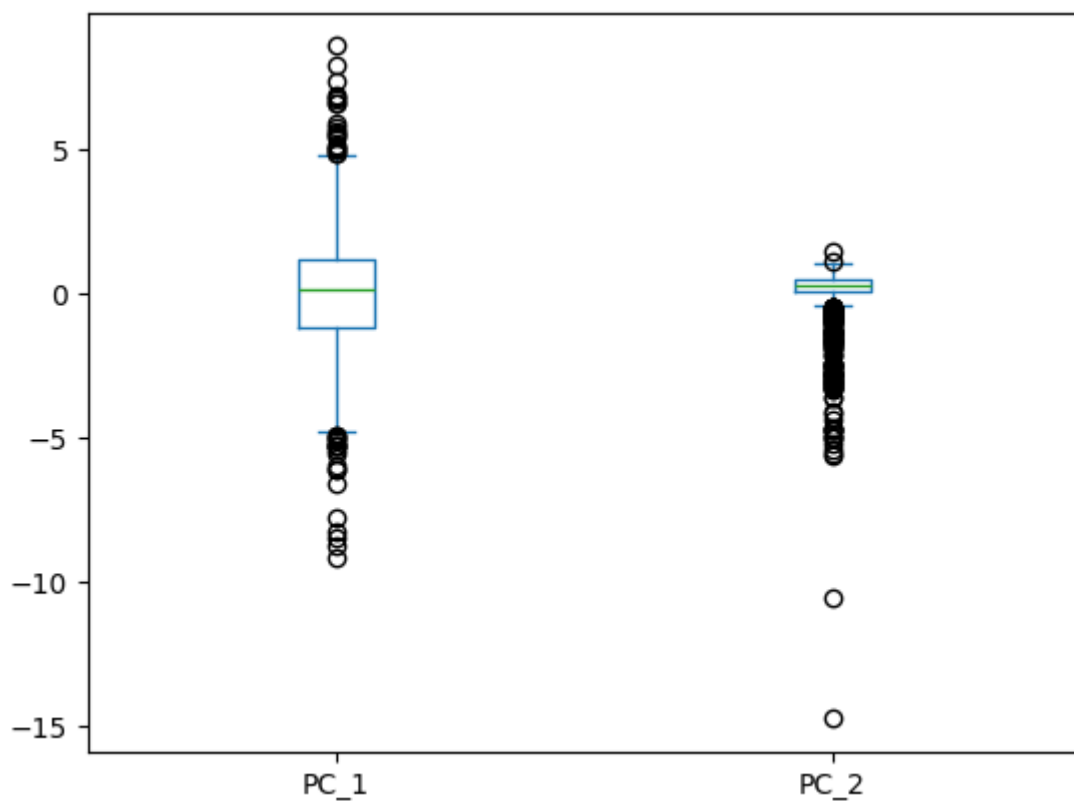
```
In [92]: df_pca = pd.DataFrame(pca_2_result, columns=['PC_1', 'PC_2'])
df_pca.head()
```

```
Out[92]:
```

	PC_1	PC_2
0	8.565309	-0.713374
1	7.920370	-0.663066
2	6.869235	-0.475166
3	6.696222	-0.467683
4	6.561643	-0.466118

```
In [93]: df_pca.plot.box()
```

```
Out[93]: <Axes: >
```

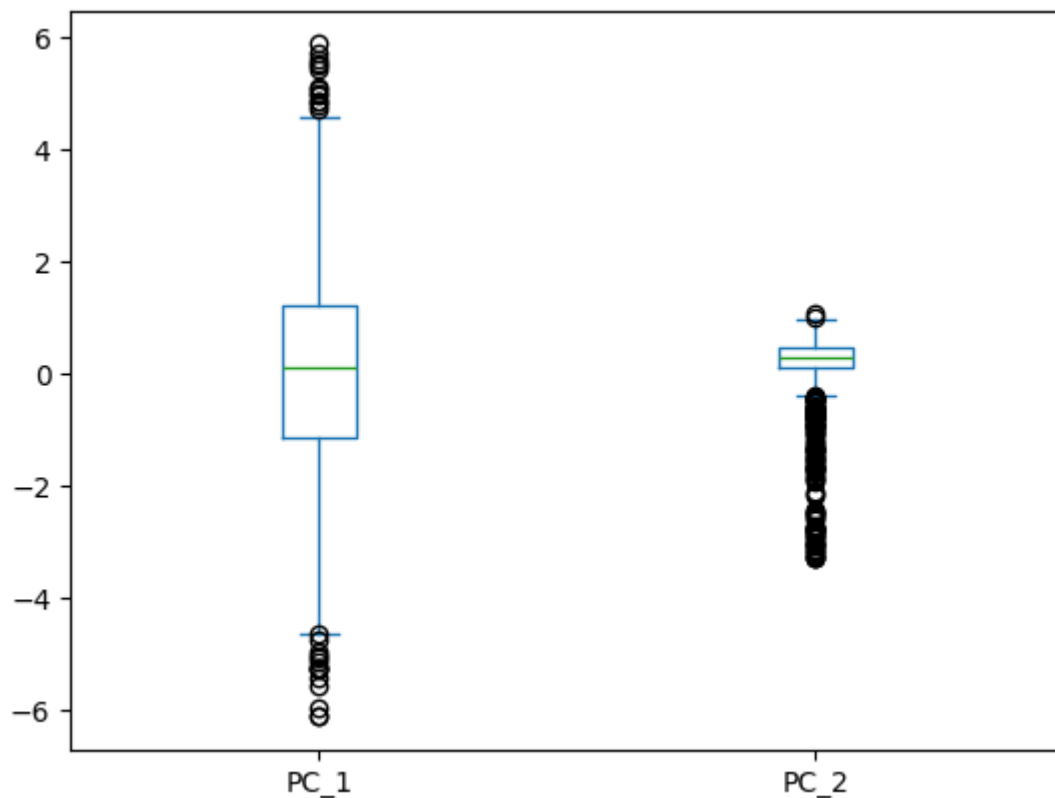


We have also introduced some serious outliers. Let's remove them

```
In [94]: z_scores = np.abs(zscore(df_pca))
df_pca = df_pca[(z_scores < 3).all(axis=1)]
```

```
In [95]: df_pca.plot.box()
```

```
Out[95]: <Axes: >
```



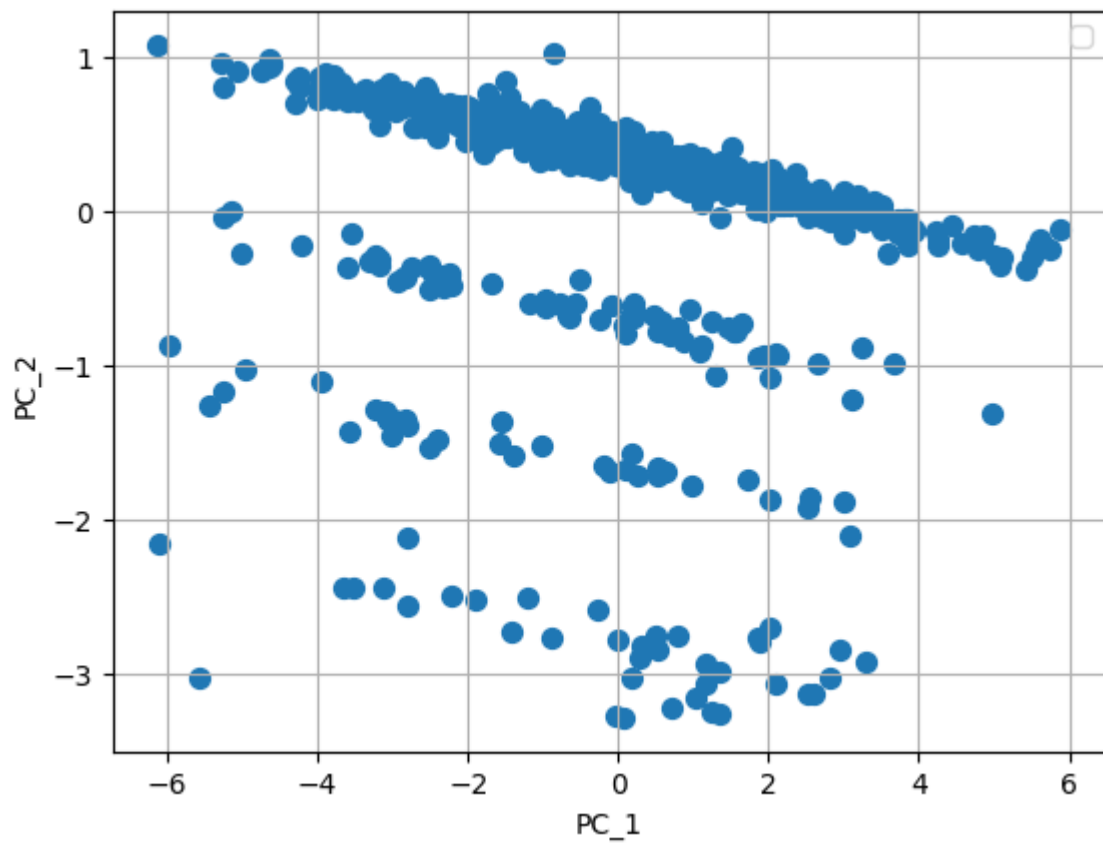
```
In [ ]: fig = plt.figure()
plt.scatter(df_pca['PC_1'], df_pca['PC_2'], s=50)
plt.xlabel('PC_1')
plt.ylabel('PC_2')
plt.grid(True)
plt.legend()
plt.show()
```

/tmp/ipykernel_12403/519479020.py:2: UserWarning: No data for colormapping provided via 'c'. Parameters 'cmap' will be ignored

```
plt.scatter(df_pca['PC_1'], df_pca['PC_2'], s=50, cmap='viridis')
```

/tmp/ipykernel_12403/519479020.py:6: UserWarning: No artists with labels found to put in legend. Note that artists whose label start with an underscore are ignored when legend() is called with no argument.

```
plt.legend()
```



```
In [97]: # Calculating optimal number of clusters in a K-means algorithm using sil
scores = []
K = range(2,10)
for k in K:
    model = KMeans(n_clusters=k, n_init=10)
    model.fit(df_pca)
    score = sk.metrics.silhouette_score(df_pca, model.labels_, metric='eu
    print("\nNumber of clusters =", k)
    print("Silhouette score =", score)
    scores.append([k, score])
```

Number of clusters = 2
Silhouette score = 0.4864683885974626

Number of clusters = 3
Silhouette score = 0.45968642227744294

Number of clusters = 4
Silhouette score = 0.4357283895887136

Number of clusters = 5
Silhouette score = 0.4764977680674508

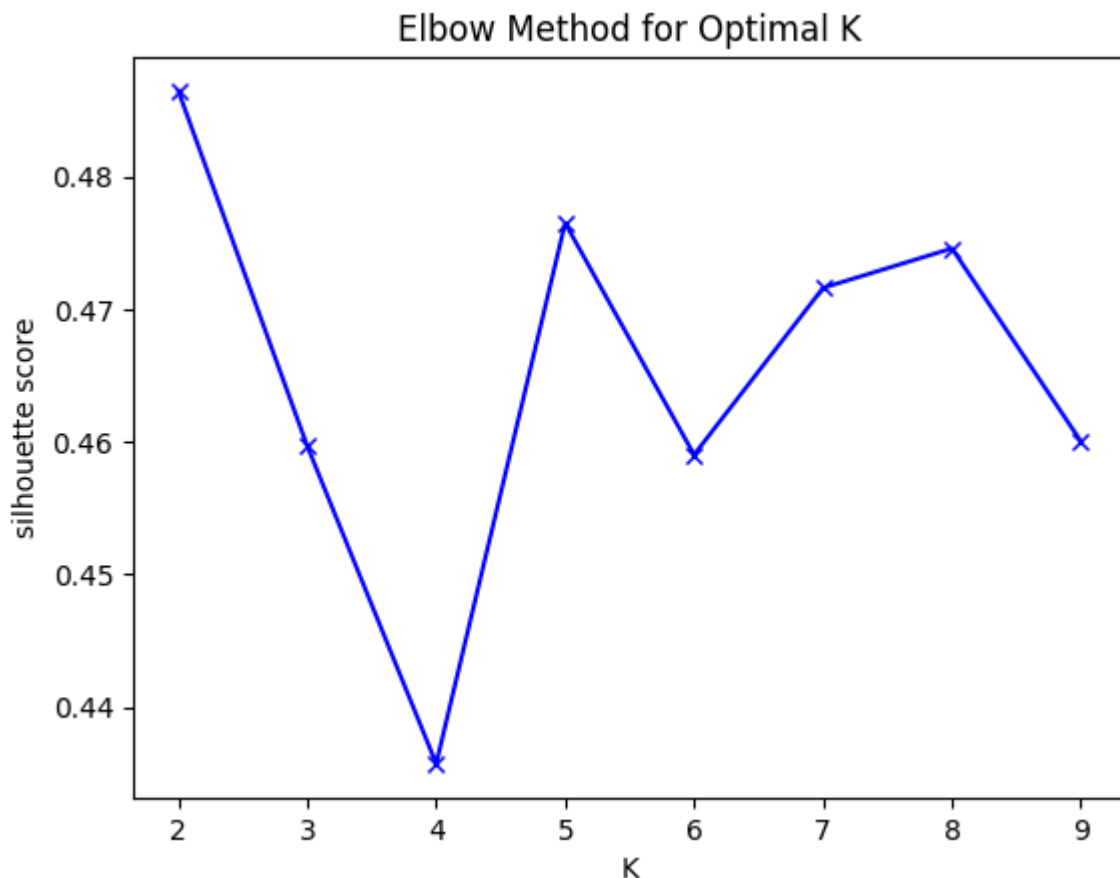
Number of clusters = 6
Silhouette score = 0.4590307090562025

Number of clusters = 7
Silhouette score = 0.4716143428820624

Number of clusters = 8
Silhouette score = 0.4745932627502572

Number of clusters = 9
Silhouette score = 0.4600339588086069

```
In [98]: score_df = pd.DataFrame(scores, columns=['k', 'scores'])
fig = plt.figure()
plt.title('Elbow Method for Optimal K')
plt.plot(score_df.k, score_df.scores, 'bx-')
plt.xlabel('K')
plt.ylabel('silhouette score')
plt.show()
```

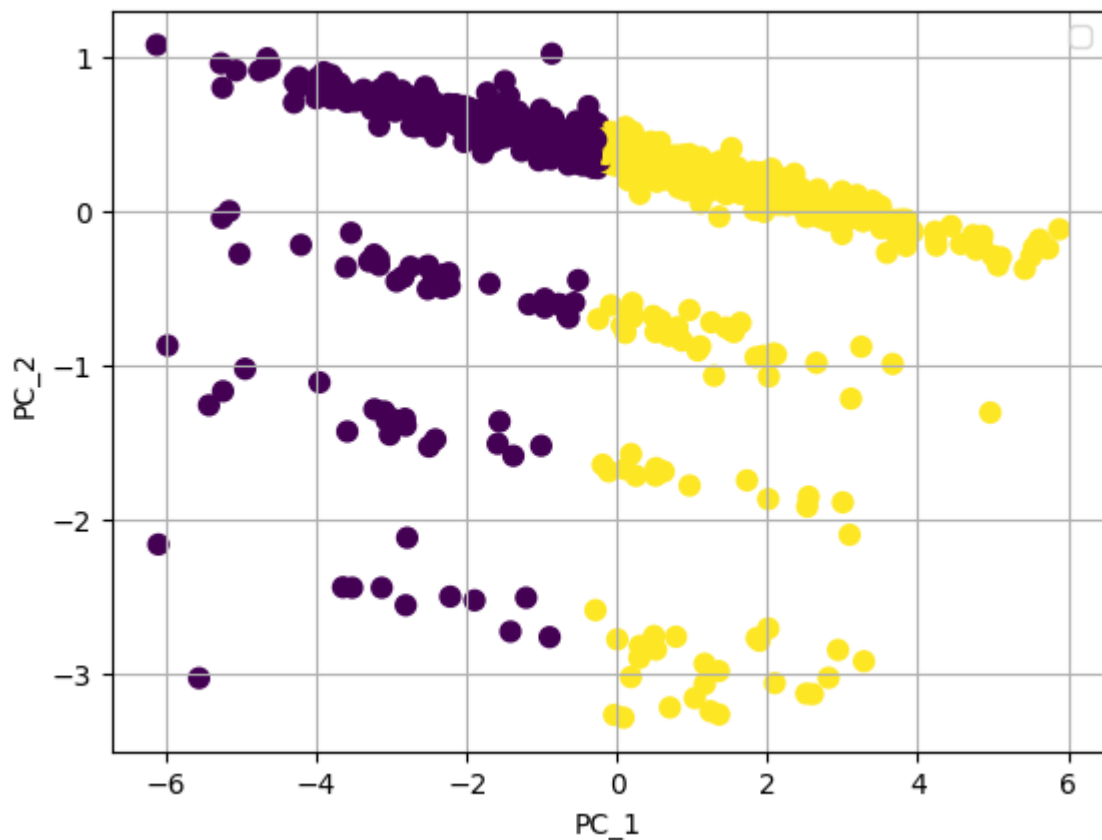


Using silhouette score for each amount of clusters, we see that we achieve a maximum score of 0,473 on 2 clusters. Let's try and visualize them

```
In [99]: kmeans = KMeans(init='k-means++', n_clusters=2, n_init=10)
         prediction = kmeans.fit_predict(df_pca)
```

```
In [100]: fig = plt.figure()
         plt.scatter(df_pca['PC_1'], df_pca['PC_2'], c=prediction, s=50, cmap='vir
         plt.xlabel('PC_1')
         plt.ylabel('PC_2')
         plt.grid(True)
         plt.legend()
         plt.show()
```

```
/tmp/ipykernel_12403/3703295130.py:6: UserWarning: No artists with labels
found to put in legend. Note that artists whose label start with an under
score are ignored when legend() is called with no argument.
  plt.legend()
```



Well, it doesn't seem like the K-means algorithm finds any clusters that makes visual sense. Let's try to do PCA again with an additional PC. The extra dimension and 10% added explained variance, might give additional insights

```
In [101]: pca_3 = PCA(n_components=3)
pca_3_result = pca_3.fit_transform(df_cls_ext)
dataset_pca = pd.DataFrame(abs(pca_3.components_), columns=df_cls_ext.columns)
dataset_pca
```

```
Out[101]:
```

	Aroma	Flavor	Acidity	Body	Balance	Aftertaste	Uniformity	Sweetness
PC_1	0.381225	0.436044	0.392771	0.381476	0.404040	0.428197	0.128396	0.0
PC_2	0.103547	0.019839	0.057700	0.113975	0.009413	0.009358	0.659328	0.7
PC_3	0.049970	0.040739	0.022757	0.067166	0.034935	0.002558	0.731547	0.6

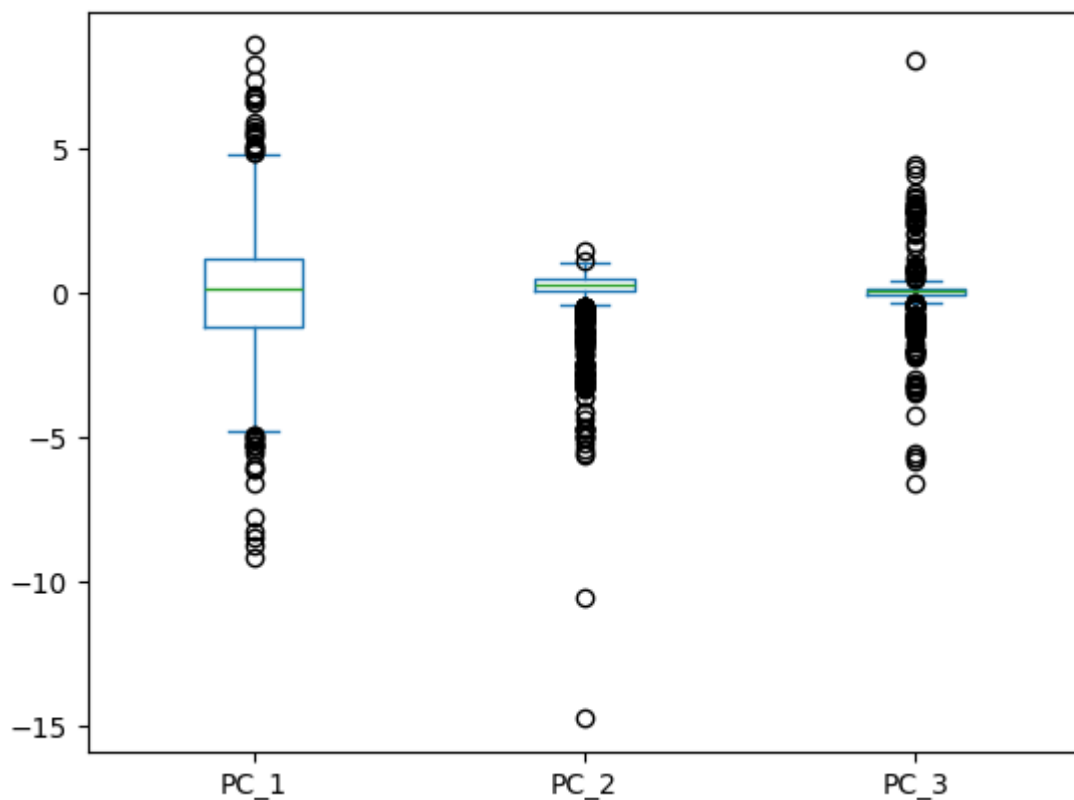
Here are our components. With PC1 weighted across most parameters, PC2 mostly weighted by Sweetness and Uniformity and PC3 weighted mainly by Uniformity

```
In [102]: df_pca = pd.DataFrame(pca_3_result, columns=['PC_1', 'PC_2', 'PC_3'])
df_pca.head()
```

```
Out[102...      PC_1      PC_2      PC_3
0  8.565309 -0.713374 -0.498447
1  7.920370 -0.663066 -0.486764
2  6.869235 -0.475166 -0.403830
3  6.696222 -0.467683 -0.395929
4  6.561643 -0.466118 -0.383813
```

```
In [103... df_pca.plot.box()
```

```
Out[103... <Axes: >
```

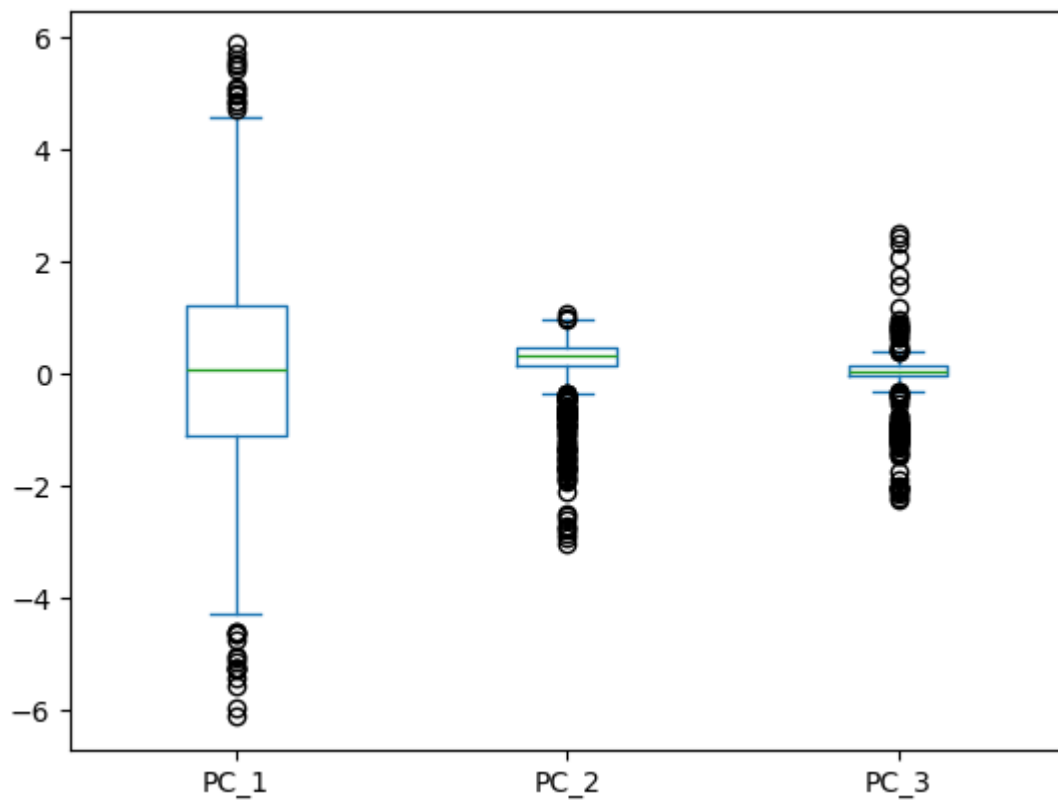


We'll remove the outliers again

```
In [104... z_scores = np.abs(zscore(df_pca))
df_pca = df_pca[(z_scores < 3).all(axis=1)]
```

```
In [105... df_pca.plot.box()
```

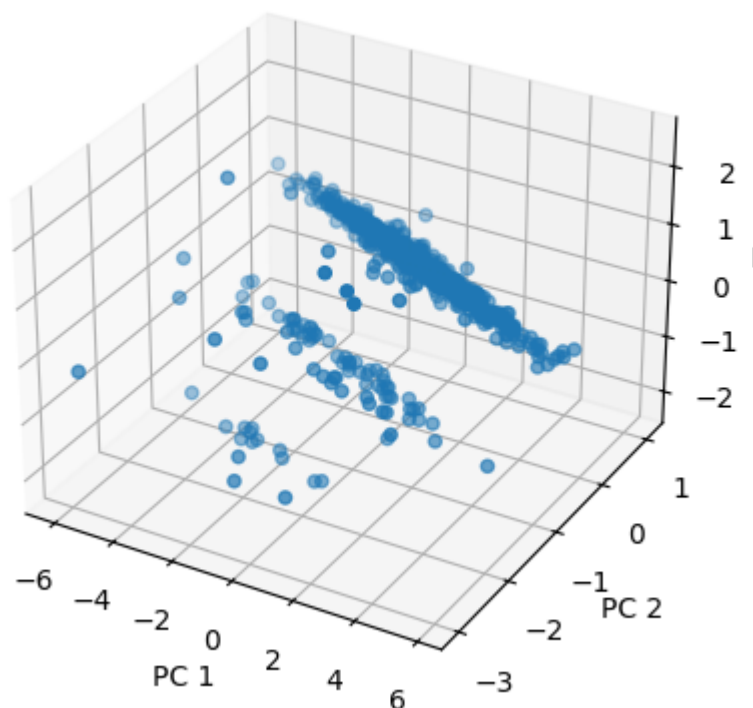
```
Out[105... <Axes: >
```

```
In [106... fig = plt.figure()
ax = fig.add_subplot(projection='3d')
ax.scatter(df_pca['PC_1'], df_pca['PC_2'], df_pca['PC_3'])

ax.set_xlabel('PC 1')
ax.set_ylabel('PC 2')
ax.set_zlabel('PC 3')
```

```
Out[106... Text(0.5, 0, 'PC 3')
```



Here is our 3D points. Let's start with doing a K-means clustering algorithm. First

we need to find the optimal K (Number of clusters)

```
In [107... # Calculating optimal number of clusters in a K-means algorithm using sil
scores = []
K = range(2,10)
for k in K:
    model = KMeans(n_clusters=k, n_init=10)
    model.fit(df_pca)
    score = sk.metrics.silhouette_score(df_pca, model.labels_, metric='eu
    print("\nNumber of clusters =", k)
    print("Silhouette score =", score)
    scores.append([k, score])
```

```
Number of clusters = 2
Silhouette score = 0.4898576695192007
```

```
Number of clusters = 3
Silhouette score = 0.4645804564710879
```

```
Number of clusters = 4
Silhouette score = 0.4376410764623363
```

```
Number of clusters = 5
Silhouette score = 0.4234582724839815
```

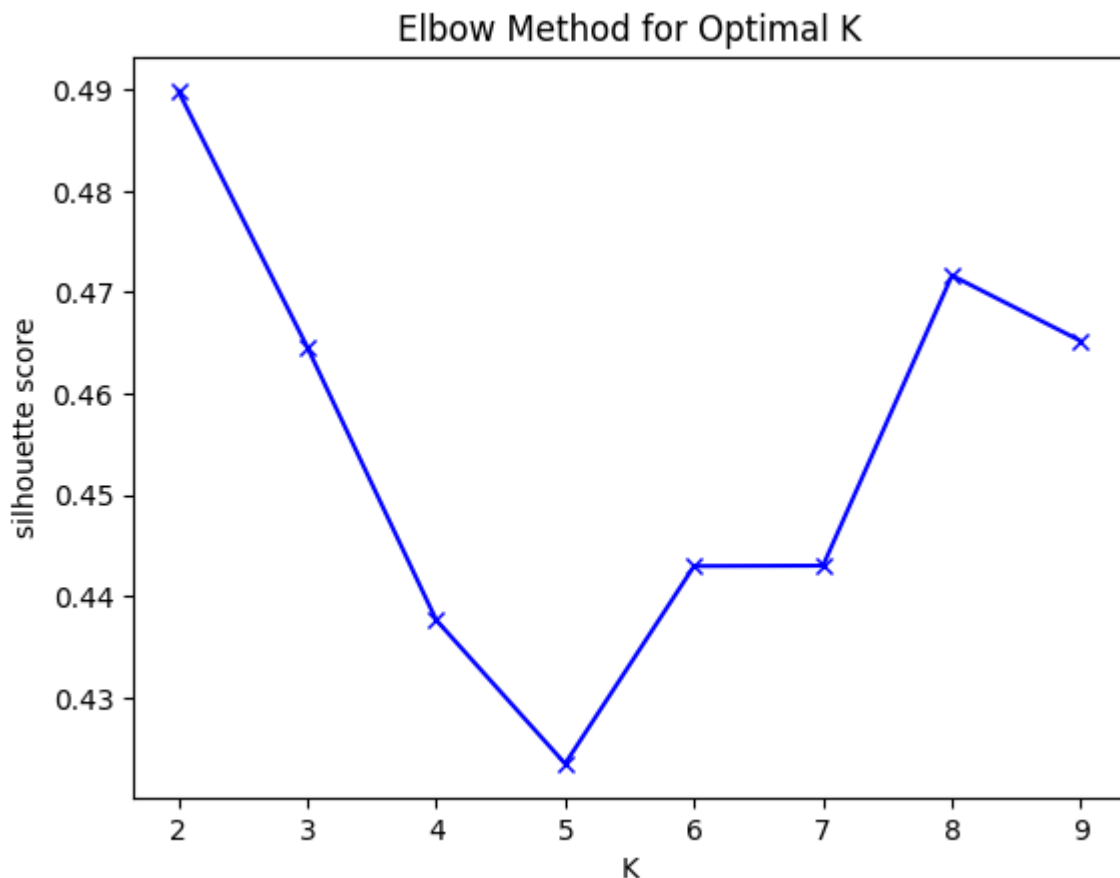
```
Number of clusters = 6
Silhouette score = 0.442960181970954
```

```
Number of clusters = 7
Silhouette score = 0.443005556219866
```

```
Number of clusters = 8
Silhouette score = 0.47164334262945723
```

```
Number of clusters = 9
Silhouette score = 0.4651752303653036
```

```
In [108... score_df = pd.DataFrame(scores, columns=['k', 'scores'])
fig = plt.figure()
plt.title('Elbow Method for Optimal K')
plt.plot(score_df.k, score_df.scores, 'bx-')
plt.xlabel('K')
plt.ylabel('silhouette score')
plt.show()
```



```
In [109... kmeans = KMeans(init='k-means++', n_clusters=2, n_init=10)
prediction = kmeans.fit_predict(df_pca)
```

```
In [110... prediction
```

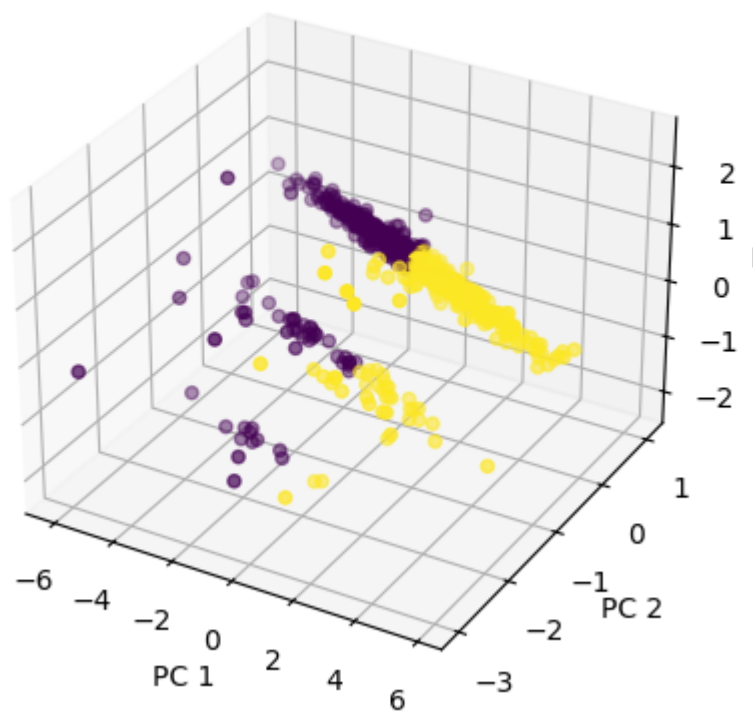
```
Out[110... array([1, 1, 1, ..., 1, 1, 1], shape=(1042,), dtype=int32)
```

```
In [111... fig = plt.figure()
fig.suptitle("K-Means")
ax = fig.add_subplot(projection='3d')
ax.scatter(df_pca['PC_1'], df_pca['PC_2'], df_pca['PC_3'], c=prediction)

ax.set_xlabel('PC 1')
ax.set_ylabel('PC 2')
ax.set_zlabel('PC 3')
```

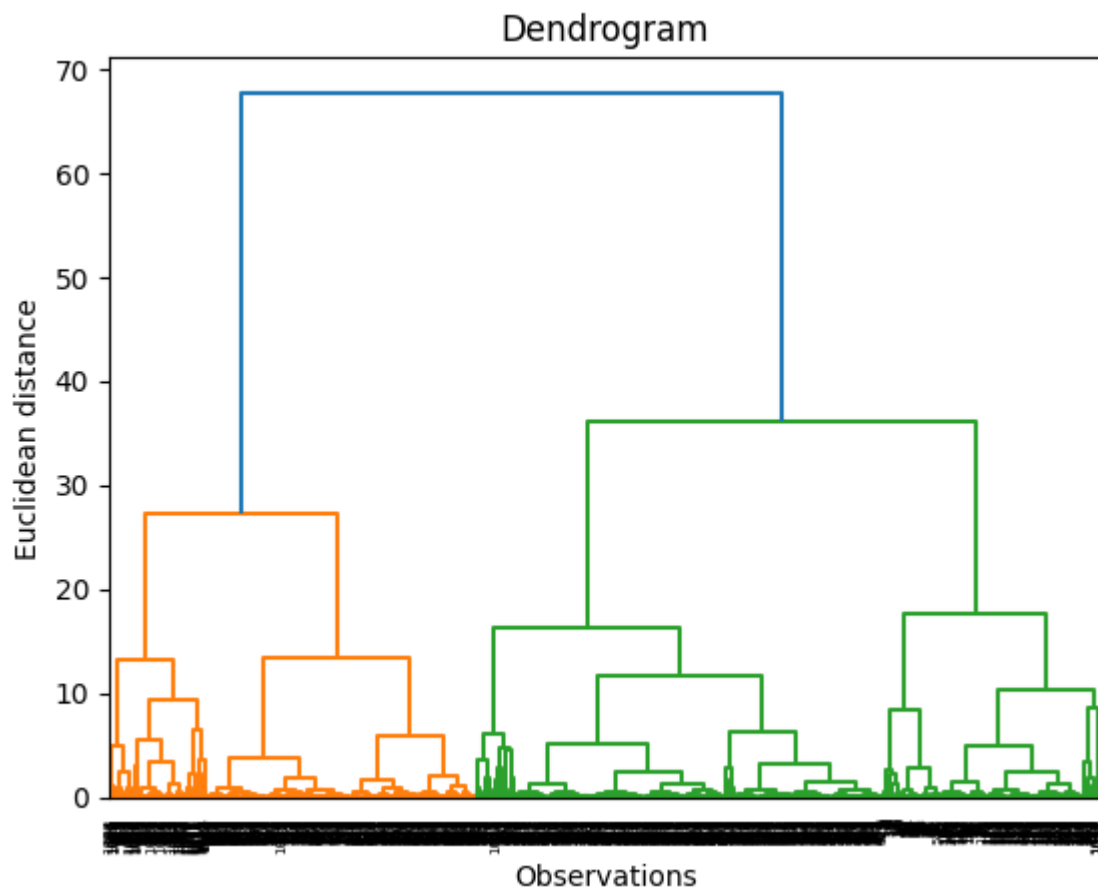
```
Out[111... Text(0.5, 0, 'PC 3')
```

K-Means



Well, the K-means method doesn't seem to agree with us. Lets try doing agglomerative clustering instead

```
In [112... # Dendrogram for agglomerative clustering
plt.figure()
dendrogram = ch.dendrogram(ch.linkage(df_pca, method = 'ward'))
plt.title('Dendrogram')
plt.xlabel('Observations')
plt.ylabel('Euclidean distance')
plt.show()
```



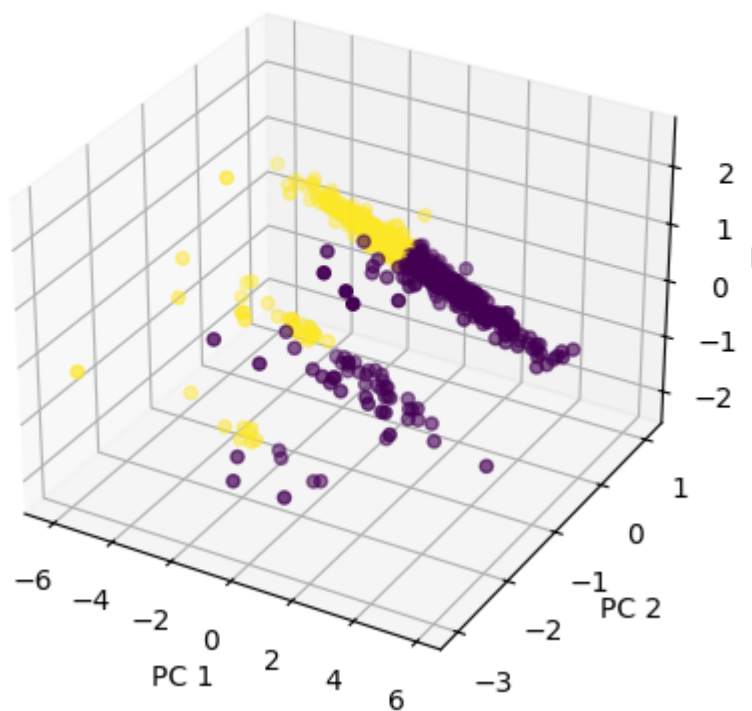
```
In [113...] model = AgglomerativeClustering(2, linkage = 'ward')
aggmodel_pred = model.fit_predict(df_pca)
```

```
In [114...] fig = plt.figure()
fig.suptitle("Agglomerative Clustering")
ax = fig.add_subplot(projection='3d')
ax.scatter(df_pca['PC_1'], df_pca['PC_2'], df_pca['PC_3'], c=aggmodel_pre

ax.set_xlabel('PC 1')
ax.set_ylabel('PC 2')
ax.set_zlabel('PC 3')
```

```
Out[114...] Text(0.5, 0, 'PC 3')
```

Agglomerative Clustering



Well that doesn't seem to agree either. Lets try running a DBSCAN

```
In [115... #DBSCAN for automatically determining amount of clusters
# Tried to play a little around with eps here
dbscan = DBSCAN(eps=0.7, min_samples=10)
dbscan_pred = dbscan.fit_predict(df_pca)
dbscan_pred
```

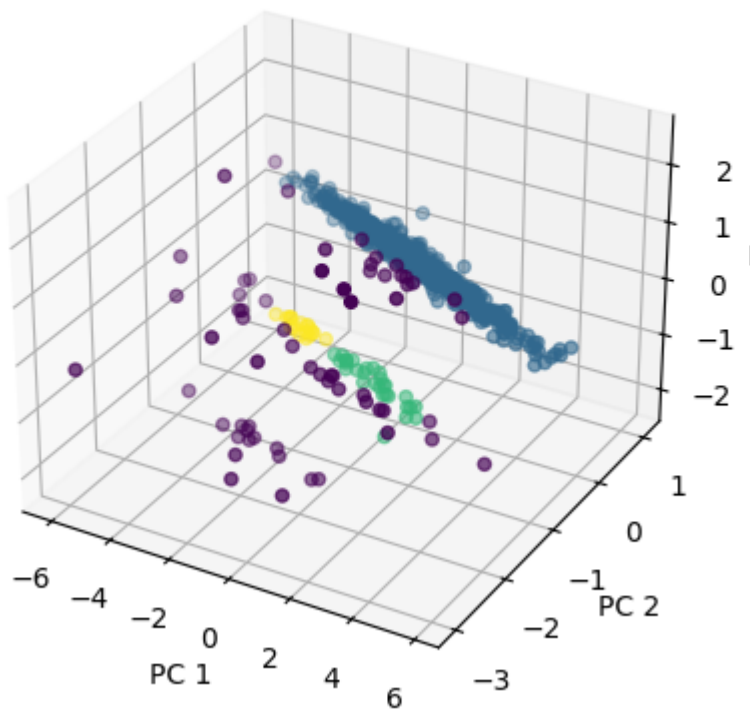
```
Out[115... array([ 0,  0,  0, ..., -1, -1, -1], shape=(1042,))
```

```
In [116... fig = plt.figure()
fig.suptitle("DBSCAN")
ax = fig.add_subplot(projection='3d')
ax.scatter(df_pca['PC_1'], df_pca['PC_2'], df_pca['PC_3'], c=dbscan_pred)

ax.set_xlabel('PC 1')
ax.set_ylabel('PC 2')
ax.set_zlabel('PC 3')
```

```
Out[116... Text(0.5, 0, 'PC 3')
```

DBSCAN



The DBSCAN clustering seems to yield the best results so far. There's a clear large cluster, showing the correlation between PC1 and PC2. Two smaller clusters showing a concentration of data points in the same correlation between PC1 and PC2, but is offset on PC2 and PC3. Showing 2 potential subcategories of data along both axes of PC2 and PC3.

In this case we suspect the clusters mostly represent the bean species, since both PC2 and PC3 are mainly weighted by Uniformity and Sweetness. We found in earlier analysis, that the main difference between Arabica and Robusta beans seem to be in sweetness. This fits with a cluster split along PC2 and PC3 axes, along with the much smaller cluster size in terms of data points, since Robusta beans are less represented in the dataset.

In summary, what we can tell about the dataset is the following:

- The Main quality measures in the coffee seems to be the flavor parameters
- It takes a large amount of defects and quakers to actually worsen the overall quality
- Arabica beans tend to be sweeter than Robusta beans
- There is a very slight indication that higher quality coffee tends to come from Africa