In [1]:

```
%matplotlib inline
import warnings
warnings.filterwarnings("ignore")


import sqlite3
import pandas as pd
import numpy as np
import nltk
import string
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.feature_extraction.text import TfidfTransformer
from sklearn.feature_extraction.text import TfidfVectorizer

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.metrics import confusion_matrix
from sklearn import metrics
from sklearn.metrics import roc_curve, auc
from nltk.stem.porter import PorterStemmer

import re
# Tutorial about Python regular expressions: https://pymotw.com/2/re/
import string
from nltk.corpus import stopwords
from nltk.stem import PorterStemmer
from nltk.stem.wordnet import WordNetLemmatizer

from gensim.models import Word2Vec
from gensim.models import KeyedVectors
import pickle

from tqdm import tqdm
import os
```

In [229]:

```
from google.colab import drive
drive.mount('/content/gdrive')
```

```
---------------------------------------------------------------------------
ImportError                               Traceback (most recent call last)
<ipython-input-229-6db90e9297aa> in <module>()
----> 1 from google.colab import drive
      2 drive.mount('/content/gdrive')

ImportError: No module named 'google.colab'
```

In [230]:

```
#connecting to sqlite db
# con = sqlite3.connect('/content/gdrive/My Drive/Colab Notebooks/Assignment 4/database.sql
con = sqlite3.connect('database.sqlite')

# filtering only positive and negative reviews i.e.
# not taking into consideration those reviews with Score=3
# SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000, will give top 500000 data points
# you can change the number to any other number based on your computing power

# filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3 LIMIT 500000
# for tsne assignment you can take 5k data points

filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews WHERE Score != 3""", con)

# Give reviews with Score>3 a positive rating(1), and reviews with a score<3 a negative rat
def partition(x):
    if x < 3:
        return 0
    return 1

#changing reviews with score less than 3 to be positive and vice-versa
actualScore = filtered_data['Score']
positiveNegative = actualScore.map(partition)
filtered_data['Score'] = positiveNegative
print("Number of data points in our data", filtered_data.shape)
filtered_data.head(3)
```

```
Number of data points in our data (525814, 10)
```

Out[230]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator	Helpfuln
0	1	B001E4KFG0	A3SGXH7AUHU8GW	delmartian	1	1
1	2	B00813GRG4	A1D87F6ZCVE5NK	dll pa	0	0
2	3	B000LQOCH0	ABXLMWJIXXAIN	Natalia Corres "Natalia Corres"	1	1

In [231]:

```
display = pd.read_sql_query("""
SELECT UserId, ProductId, ProfileName, Time, Score, Text, COUNT(*)
FROM Reviews
GROUP BY UserId
HAVING COUNT(*)>1
""", con)
```

In [232]:

```
print(display.shape)
display.head()
```

```
(80668, 7)
```

Out[232]:

	UserId	ProductId	ProfileName	Time	Score	Text	CO
0	#oc-R115TNMSPFT9I7	B007Y59HVM	Breyton	1331510400	2	Overall its just OK when considering the price...	2
1	#oc-R11D9D7SHXIJB9	B005HG9ET0	Louis E. Emory "hoppy"	1342396800	5	My wife has recurring extreme muscle spasms, u...	3
2	#oc-R11DNU2NBKQ23Z	B007Y59HVM	Kim Cieszykowski	1348531200	1	This coffee is horrible and unfortunately not ...	2
3	#oc-R11O5J5ZVQE25C	B005HG9ET0	Penguin Chick	1346889600	5	This will be the bottle that you grab from the...	3
4	#oc-R12KPBODL2B5ZD	B007OSBE1U	Christopher P. Presta	1348617600	1	I didnt like this coffee. Instead of telling y...	2

In [233]:

```
# Removing duplicate reviews
final=filtered_data.drop_duplicates(subset={"UserId","ProfileName","Time","Text"}, keep='fi
print(final.shape)
```

```
(364173, 10)
```

In [234]:

```
(final['Id'].size*1.0)/(filtered_data['Id'].size*1.0)*100
```

Out[234]:

```
69.25890143662969
```

In [235]:

```
final=final[final.HelpfulnessNumerator<=final.HelpfulnessDenominator]
```

In [236]:

```
#Before starting the next phase of preprocessing lets see the number of entries left
print(final.shape)

#How many positive and negative reviews are present in our dataset?
final['Score'].value_counts()
```

```
(364171, 10)
```

Out[236]:

```
1    307061
0     57110
Name: Score, dtype: int64
```

In [237]:

```
final["cleanReview"] = final["Summary"].map(str) + ". " + final["Text"]
```

In [238]:

```
final['cleanReview'].head()
```

Out[238]:

```
0    Good Quality Dog Food. I have bought several o...
1    Not as Advertised. Product arrived labeled as ...
2    "Delight" says it all. This is a confection th...
3    Cough Medicine. If you are looking for the sec...
4    Great taffy. Great taffy at a great price.  Th...
Name: cleanReview, dtype: object
```

In [239]:

```
final['lengthOfReview'] = final['cleanReview'].str.split().str.len()
final['lengthOfReview'].head()
```

Out[239]:

```
0    52
1    34
2    98
3    43
4    29
Name: lengthOfReview, dtype: int64
```

In [19]:

```
#remove urls from text python
from tqdm import tqdm
lst = []
removed_urls_list = []
for text in tqdm(final['cleanReview']):
  removed_urls_text = re.sub(r"http\S+", "", text)
  lst.append(removed_urls_text)
```

```
100%|███████████████████████████████████████████████████████████████████████
██████████████████████████████████████████████████████| 364171/364171 [00:01
<00:00, 348689.13it/s]
```

In [20]:

```
#remove urls from text python
removed_urls_list = []
for text in tqdm(lst):
  removed_urls_text = re.sub(r"http\S+", "", text)
  removed_urls_list.append(removed_urls_text)
```

```
100%|███████████████████████████████████████████████████████████████████████
██████████████████████████████████████████████████████| 364171/364171 [00:00
<00:00, 545983.46it/s]
```

In [21]:

```
from bs4 import BeautifulSoup
text_lst = []
for text in tqdm(removed_urls_list):
  soup = BeautifulSoup(text, 'lxml')
  text = soup.get_text()
  text_lst.append(text)
# print(text)
# print("="*50)
```

```
100%|███████████████████████████████████████████████████████████████████████
████████████████████████████████████████████████████████| 364171/364171 [02:
07<00:00, 2863.46it/s]
```

In [22]:

```
print(len(final['cleanReview']))
```

```
364171
```

In [23]:

```
# https://stackoverflow.com/a/47091490/4084039
import re

def decontracted(phrase):
    # specific
    phrase = re.sub(r"won't", "will not", phrase)
    phrase = re.sub(r"can\'t", "can not", phrase)

    # general
    phrase = re.sub(r"n\'t", " not", phrase)
    phrase = re.sub(r"\'re", " are", phrase)
    phrase = re.sub(r"\'s", " is", phrase)
    phrase = re.sub(r"\'d", " would", phrase)
    phrase = re.sub(r"\'ll", " will", phrase)
    phrase = re.sub(r"\'t", " not", phrase)
    phrase = re.sub(r"\'ve", " have", phrase)
    phrase = re.sub(r"\'m", " am", phrase)
    return phrase
```

In [24]:

```
decat_lst = []
for decat_text in tqdm(text_lst):
  text = decontracted(decat_text)
  decat_lst.append(text)
```

```
100%|███████████████████████████████████████████████████████████████████████
███████████████████████████████████████████████████████| 364171/364171 [00:0
5<00:00, 67496.57it/s]
```

In [25]:

```
strip_list = []
for to_strip in tqdm(decat_lst):
  text = re.sub("\S*\d\S*", "", to_strip).strip()
  strip_list.append(text)
```

```
100%|███████████████████████████████████████████████████████████████████████
███████████████████████████████████████████████████████| 364171/364171 [00:1
9<00:00, 18494.66it/s]
```

In [26]:

```
spatial_list = []
for to_spatial in tqdm(strip_list):
  text = re.sub('[^A-Za-z0-9]+', ' ', to_spatial)
  spatial_list.append(text)
```

```
100%|███████████████████████████████████████████████████████████████████████
███████████████████████████████████████████████████████| 364171/364171 [00:0
9<00:00, 36464.50it/s]
```

In [27]:

```
stopwords= set(['br', 'the', 'i', 'me', 'my', 'myself', 'we', 'our', 'ours', 'ourselves', '
            "you'll", "you'd", 'your', 'yours', 'yourself', 'yourselves', 'he', 'him', 'his
            'she', "she's", 'her', 'hers', 'herself', 'it', "it's", 'its', 'itself', 'they'
            'theirs', 'themselves', 'what', 'which', 'who', 'whom', 'this', 'that', "that'l
            'am', 'is', 'are', 'was', 'were', 'be', 'been', 'being', 'have', 'has', 'had',
            'did', 'doing', 'a', 'an', 'the', 'and', 'but', 'if', 'or', 'because', 'as', 'u
            'at', 'by', 'for', 'with', 'about', 'against', 'between', 'into', 'through', 'd
            'above', 'below', 'to', 'from', 'up', 'down', 'in', 'out', 'on', 'off', 'over',
            'then', 'once', 'here', 'there', 'when', 'where', 'why', 'how', 'all', 'any', '
            'most', 'other', 'some', 'such', 'only', 'own', 'same', 'so', 'than', 'too', 'v
            's', 't', 'can', 'will', 'just', 'don', "don't", 'should', "should've", 'now',
            've', 'y', 'ain', 'aren', "aren't", 'couldn', "couldn't", 'didn', "didn't", 'do
            "hadn't", 'hasn', "hasn't", 'haven', "haven't", 'isn', "isn't", 'ma', 'mightn',
            "mustn't", 'needn', "needn't", 'shan', "shan't", 'shouldn', "shouldn't", 'wasn'
            'won', "won't", 'wouldn', "wouldn't"])
```

In [28]:

```
# Combining all the above stundents
preprocessed_reviews = []
# tqdm is for printing the status bar
for sentance in tqdm(spatial_list):
    sentance = re.sub(r"http\S+", "", sentance)
    sentance = BeautifulSoup(sentance, 'lxml').get_text()
    sentance = decontracted(sentance)
    sentance = re.sub("\S*\d\S*", "", sentance).strip()
    sentance = re.sub('[^A-Za-z]+', ' ', sentance)
    # https://gist.github.com/sebleier/554280
    sentance = ' '.join(e.lower() for e in sentance.split() if e.lower() not in stopwords)
    preprocessed_reviews.append(sentance.strip())
```

```
100%|███████████████████████████████████
████████████████████████████| 364171/364171 [02:
01<00:00, 2999.66it/s]
```

In [29]:

```
print(len(preprocessed_reviews))
preprocessed_reviews[-1]
```

```
364171
```

Out[29]:

```
'great honey satisfied product advertised use cereal raw vinegar general swe
etner'
```

In [30]:

```
final['cleanReview'] = preprocessed_reviews
```

In [117]:

```
print(len(final))
final.tail(5)
```

```
364171
```

Out[117]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator
525809	568450	B001EO7N10	A28KG5XORO54AY	Lettie D. Carter	0
525810	568451	B003S1WTCU	A3I8AFVPEE8KI5	R. Sawyer	0
525811	568452	B004I613EE	A121AA1GQV751Z	pksd "pk_007"	2
525812	568453	B004I613EE	A3IBEVCTXKNOH	Kathy A. Welch "katwel"	1
525813	568454	B001LR2CU2	A3LGQPJCZVL9UC	srfell17	0

In [118]:

```
final['cleanReview'][0]
```

Out[118]:

```
'good quality dog food bought several vitality canned dog food products foun
d good quality product looks like stew processed meat smells better labrador
finicky appreciates product better'
```

In [119]:

```
final['lengthOfReview'][0]
```

Out[119]:

```
27
```

In [2]:

```
dir_path = os.getcwd()
# conn = sqlite3.connect(os.path.join(dir_path, '/content/gdrive/My Drive/Colab Notebooks/A
conn = sqlite3.connect(os.path.join(dir_path, 'final.sqlite'))
# final.to_sql('Reviews', conn, if_exists='replace', index=False)
```

In [3]:

```
review_3 = pd.read_sql_query(""" SELECT count(*) FROM Reviews""", conn)
print(review_3)
```

```
   count(*)
0    364171
```

In [4]:

```
filtered_data = pd.read_sql_query(""" SELECT * FROM Reviews""", conn)
```

In [5]:

```
filtered_data.shape
```

Out[5]:

```
(364171, 12)
```

In [6]:

```
filtered_data["Time"] = pd.to_datetime(filtered_data["Time"], unit = "s")
filtered_data = filtered_data.sort_values(by = "Time")
```

In [7]:

```
filtered_data.head(5)
```

Out[7]:

	Id	ProductId	UserId	ProfileName	HelpfulnessNumerator
117924	150524	0006641040	ACITT7DI6IDDL	shari zychinski	0
117901	150501	0006641040	AJ46FKXOVC7NR	Nicholas A Mesiano	2
298792	451856	B00004CXX9	AIUWLEQ1ADEG5	Elizabeth Medina	0
169281	230285	B00004RYGX	A344SMIA5JECGM	Vincent P. Ross	1
298791	451855	B00004CXX9	AJH6LUC1UT1ON	The Phantom of the Opera	0

In [8]:

```
print(len(filtered_data))
filtered_data.info()
filtered_data = filtered_data.head(100000)
print(len(filtered_data))
```

```
364171
<class 'pandas.core.frame.DataFrame'>
Int64Index: 364171 entries, 117924 to 107253
Data columns (total 12 columns):
Id                        364171 non-null int64
ProductId                 364171 non-null object
UserId                    364171 non-null object
ProfileName               364171 non-null object
HelpfulnessNumerator      364171 non-null int64
HelpfulnessDenominator    364171 non-null int64
Score                     364171 non-null int64
Time                      364171 non-null datetime64[ns]
Summary                   364171 non-null object
Text                      364171 non-null object
cleanReview               364171 non-null object
lengthOfReview            364171 non-null int64
dtypes: datetime64[ns](1), int64(5), object(6)
memory usage: 36.1+ MB
100000
```

In [9]:

```
filtered_data['Score'].value_counts()
```

Out[9]:

```
1    87729
0    12271
Name: Score, dtype: int64
```

In [10]:

```
X = filtered_data["cleanReview"]
print(print("shape of X:", X.head(5)))
y = filtered_data["Score"]
print("shape of y:", y.head(5))
X_len = filtered_data['lengthOfReview']
```

```
shape of X: 117924    every book educational witty little book makes...
117901    whole series great way spend time child rememb...
298792    entertainingl funny beetlejuice well written m...
169281    modern day fairy tale twist rumplestiskin capt...
298791    fantastic beetlejuice excellent funny movie ke...
Name: cleanReview, dtype: object
None
shape of y: 117924    1
117901    1
298792    1
169281    1
298791    1
Name: Score, dtype: int64
```

In [11]:

```
len(filtered_data['lengthOfReview'])
```

Out[11]:

```
100000
```

In [12]:

```
X_train = X[0:100000]
Y_train = y[0:100000]
```

In [13]:

```
print(len(X_train))
print(len(Y_train))
```

```
100000
100000
```

In [14]:

```
print(X_train.shape)
print(X_train.shape)
```

```
(100000,)
(100000,)
```

Bag of Words

In [15]:

```
from sklearn.feature_extraction.text import CountVectorizer

count_vect = CountVectorizer()
X_train_vect = count_vect.fit_transform(X_train)
X_test_vect = count_vect.transform(X_test)
X_val_vect = count_vect.transform(X_val)
feature_names = count_vect.get_feature_names()
# BoW_dict = {'X_train_vect':X_train_vect, 'X_test_vect': X_test_vect, 'X_val_vect': X_val_
print(X_train_vect.shape)
# print(feature_names)
```

```
(60000, 48270)
```

In [16]:

```
X_train_vect.shape
```

Out[16]:

```
(60000, 48270)
```

In [18]:

```
len(filtered_data['lengthOfReview'])
```

Out[18]:

```
100000
```

In [191]:

```
from scipy.sparse import hstack
# len_review = final['lengthOfReview'].to_sparse()
concat_data = hstack((X_train_vect,np.array(filtered_data['lengthOfReview'][0:60000])[:,Nor
concat_data_val = hstack((X_val_vect,np.array(filtered_data['lengthOfReview'][60000:80000])
concat_data_test = hstack((X_test_vect,np.array(filtered_data['lengthOfReview'][80000:10000
```

In [193]:

```
print(concat_data.shape)
print(concat_data_val.shape)
print(concat_data_test.shape)
```

```
(60000, 47536)
(20000, 47536)
(20000, 47536)
```

In [194]:

```
print(len(feature_names))
```

```
47535
```

In [195]:

```
BoW_dict = {'X_train_vect':concat_data, 'X_test_vect': concat_data_test, 'X_val_vect': conc
print(BoW_dict['X_train_vect'].shape)
```

```
(60000, 47536)
```

In [196]:

```
import pickle
with open('BoW.pkl', 'wb') as handle:
    pickle.dump(BoW_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

TF-IDF

In [17]:

```
tf_idf_vect = TfidfVectorizer(ngram_range=(1,2), min_df=10)
train_tf_idf = tf_idf_vect.fit_transform(X_train)

print("the shape of out text TFIDF vectorizer ",train_tf_idf.get_shape())
print("the type of count vectorizer ",type(train_tf_idf))
print("the number of unique words including both unigrams and bigrams ", train_tf_idf.get_s
```

```
the shape of out text TFIDF vectorizer  (100000, 59901)
the type of count vectorizer  <class 'scipy.sparse.csr.csr_matrix'>
the number of unique words including both unigrams and bigrams  59901
```

In [18]:

```
tf_idf_dict = {'train_tf_idf': train_tf_idf}
```

In [19]:

```
import pickle
with open('tf_idf.pkl', 'wb') as handle:
    pickle.dump(tf_idf_dict, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

TruncatedSVD on tfidf

In [15]:

```
import pickle
# with open(r"/content/gdrive/My Drive/Colab Notebooks/Assignment 4/tf_idf.pkl", "rb") as i
with open(r"tf_idf.pkl", "rb") as input_file:
    tfidf_dict = pickle.load(input_file)
```

In [20]:

```
from sklearn.decomposition import TruncatedSVD

svd = TruncatedSVD()
svd.fit(train_tf_idf)
```

Out[20]:

```
TruncatedSVD(algorithm='randomized', n_components=2, n_iter=5,
       random_state=None, tol=0.0)
```

In [21]:

```
idf = tf_idf_vect.idf_
y = dict(zip(tf_idf_vect.get_feature_names(), idf))
```

In [22]:

```
from collections import OrderedDict
from operator import itemgetter

sorted_dict = OrderedDict(sorted(y.items(), key = itemgetter(1), reverse=True))
```

In [23]:

```
top_features = list(sorted_dict)[:2000]
```

In [24]:

```
print(len(top_features))
top_features[0]
```

```
2000
```

Out[24]:

```
'enough calories'
```

In [25]:

```
top_features
```

```
 'seems no',
 'best jerk',
 'save product',
 'chive',
 'happy well',
 'recipes website',
 'home us',
 'use rub',
 'not rock',
 'thumbs one',
 'based amazon',
 'dried parsley',
 'aftertaste product',
 'two tins',
 'anymore bought',
 'animal product',
 'scientifically',
 'love rooibos',
 'italian seasonings',
 'since flavor',
```

co-occurrence matrix

In [26]:

```
#https://stackoverflow.com/questions/35562789/how-do-i-calculate-a-word-word-co-occurrence-
count_model = CountVectorizer(ngram_range=(1,2))
X = count_model.fit_transform(top_features)
```

In [27]:

```
Xc = (X.T * X)
```

In [28]:

```
Xc.setdiag(0)
```

In [29]:

```
print(Xc.todense())
```

```
[[0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 ...
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]
 [0 0 0 ... 0 0 0]]
```

In [31]:

```
print(Xc)
Xc.shape
```

```
  (0, 0)	0
  (2924, 1)	1
  (1, 1)	0
  (2925, 1)	1
  (3009, 2)	1
  (3010, 2)	1
  (32, 2)	1
  (3, 2)	1
  (2, 2)	0
  (1498, 2)	1
  (4, 2)	1
  (2, 3)	1
  (32, 3)	1
  (3, 3)	0
  (2, 4)	1
  (1498, 4)	1
  (4, 4)	0
  (1957, 5)	1
  (5, 5)	0
  (6, 5)	1
  (1957, 6)	1
  (5, 6)	1
  (6, 6)	0
  (1975, 7)	1
  (7, 7)	0
  :	:
  (1651, 3286)	1
  (3286, 3286)	0
  (1673, 3286)	1
  (3287, 3287)	0
  (3082, 3288)	1
  (3288, 3288)	0
  (3289, 3288)	1
  (3082, 3289)	1
  (3288, 3289)	1
  (3289, 3289)	0
  (3290, 3290)	0
  (916, 3291)	1
  (3292, 3291)	1
  (2690, 3291)	1
  (3291, 3291)	0
  (3293, 3291)	1
  (916, 3292)	1
  (3291, 3292)	1
  (3292, 3292)	0
  (2690, 3293)	1
  (3291, 3293)	1
  (3293, 3293)	0
  (2325, 3294)	1
  (3294, 3294)	0
  (2329, 3294)	1
```

Out[31]:

```
(3295, 3295)
```

In [26]:

```
type(train_tf_idf)
```

Out[26]:

```
scipy.sparse.csr.csr_matrix
```

In [27]:

```
from sklearn.decomposition import PCA
from sklearn.preprocessing import MinMaxScaler
```

In [85]:

```
#https://towardsdatascience.com/an-approach-to-choosing-the-number-of-components-in-a-princ

#Fitting the Truncated SVD algorithm with our Data
tsvd = TruncatedSVD(n_components=50).fit(m)
```

In [86]:

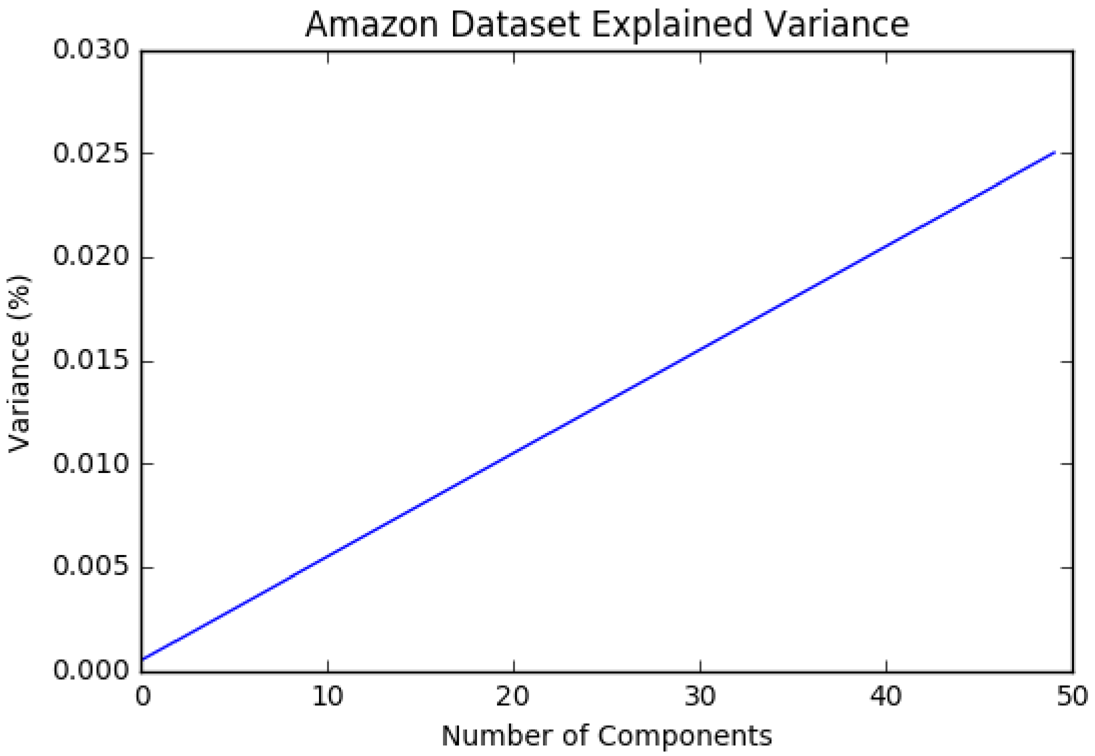
```
tsvd.explained_variance_ratio_
```

Out[86]:

```
array([0.00050035, 0.00049886, 0.00050025, 0.00049901, 0.0005005 ,
       0.00050034, 0.00050009, 0.00050044, 0.00050049, 0.0005001 ,
       0.00050048, 0.0005005 , 0.00050046, 0.00049928, 0.00049991,
       0.0005001 , 0.00050003, 0.00050045, 0.00050049, 0.00050034,
       0.00049951, 0.00050048, 0.00050047, 0.00050014, 0.00050049,
       0.00050048, 0.00050019, 0.00050013, 0.00049987, 0.00050045,
       0.00050048, 0.0005005 , 0.00050023, 0.00050046, 0.00050039,
       0.00050038, 0.00050012, 0.00050041, 0.00049976, 0.00050033,
       0.00050045, 0.00050037, 0.00050025, 0.00050045, 0.00050028,
       0.00050035, 0.0005005 , 0.00050032, 0.00049854, 0.00049977])
```

In [87]:

```
#Plotting the Cumulative Summation of the Explained Variance
plt.figure()
plt.plot(np.cumsum(tsvd.explained_variance_ratio_))
plt.xlabel('Number of Components')
plt.ylabel('Variance (%)') #for each component
plt.title('Amazon Dataset Explained Variance')
plt.show()
```



In [31]:

```
best_svd = TruncatedSVD(n_components=1).fit(train_tf_idf)
```

In [ ]:

```
from sklearn.cluster import KMeans
from sklearn.model_selection import GridSearchCV
from tqdm import tqdm
tfidf_k_inertia_train = dict()

for k_val in range(1, 8):
    tfidf_km_clf = KMeans(n_clusters = k_val, n_jobs = -1)
    tfidf_km_clf.fit(train_tf_idf)
    tfidf_k_inertia_train[k_val] = (tfidf_km_clf.inertia_)
```

In [33]:

```
tfidf_k_inertia_train
```

Out[33]:

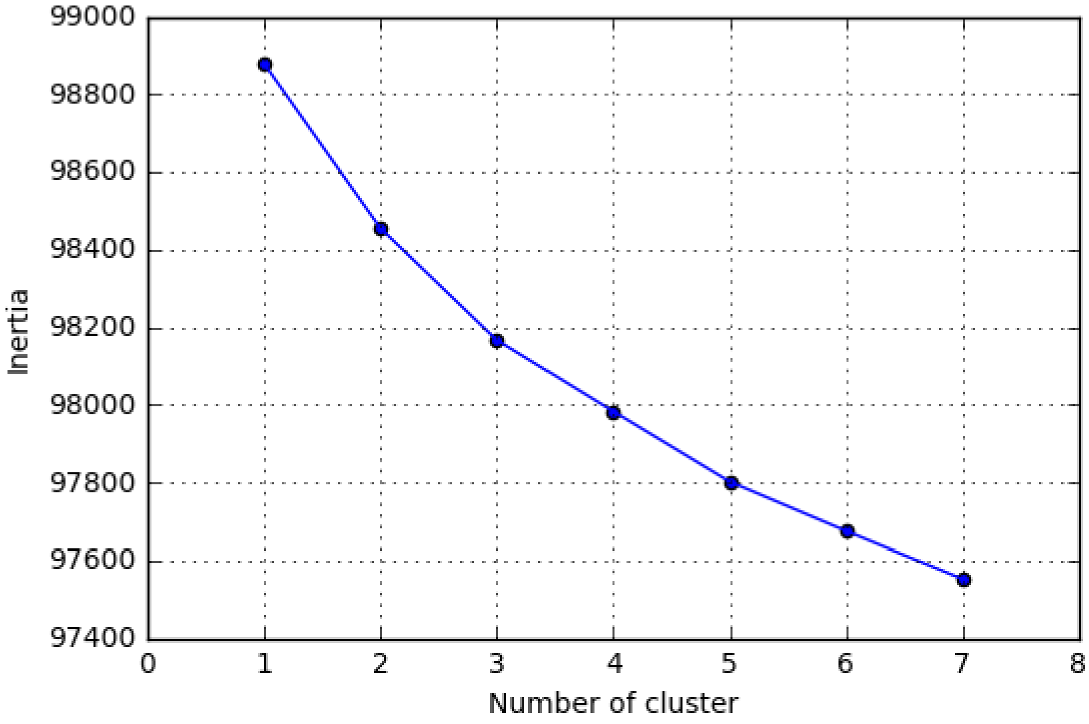
```
{1: 98878.82946187379,
 2: 98455.39946212494,
 3: 98166.69384298568,
 4: 97982.62814136724,
 5: 97801.75092993751,
 6: 97675.24596462022,
 7: 97551.88000632105}
```

In [34]:

```
with open('cluster_dict.pkl', 'wb') as handle:
 pickle.dump(tfidf_k_inertia_train, handle, protocol=pickle.HIGHEST_PROTOCOL)
```

In [35]:

```
plt.figure()
plt.plot(list(tfidf_k_inertia_train.keys()), list(tfidf_k_inertia_train.values()))
plt.scatter(list(tfidf_k_inertia_train.keys()), list(tfidf_k_inertia_train.values()))
plt.xlabel("Number of cluster")
plt.ylabel("Inertia")
plt.grid()
plt.show()
```



Training with 7 clusters

In [ ]:

```
import datetime

t1 = datetime.datetime.now()
tfidf_final_clf = KMeans(n_clusters = 7, n_jobs = -1)
tfidf_final_clf.fit(train_tf_idf)
print("time required = ",datetime.datetime.now() - t1 )
```

```
time required =  0:48:57.536801
```

In [44]:

```
from wordcloud import WordCloud
imp_features_tfidf = []
print("Top terms per cluster:")
order_centroids = tfidf_final_clf.cluster_centers_.argsort()[:, ::-1]
terms = tf_idf_vect.get_feature_names()
print(len(terms))
for i in range(7):
    for ind in order_centroids[i, :20]:
        imp_featues_dict = {}
        imp_featues_dict[i] = terms[ind-1]
        imp_features_tfidf.append(imp_featues_dict)
```

```
Top terms per cluster:
59901
```

In [45]:

```
len(imp_features_tfidf)
```

Out[45]:

```
140
```

In [53]:

```
cl1 = [d[0] for d in imp_features_tfidf if 0 in d]
cl2 = [d[1] for d in imp_features_tfidf if 1 in d]
cl3 = [d[2] for d in imp_features_tfidf if 2 in d]
cl4 = [d[3] for d in imp_features_tfidf if 3 in d]
cl5 = [d[4] for d in imp_features_tfidf if 4 in d]
cl6 = [d[5] for d in imp_features_tfidf if 5 in d]
cl7 = [d[6] for d in imp_features_tfidf if 6 in d]
print(cl1, cl2, cl3, cl4, cl5, cl6)
```

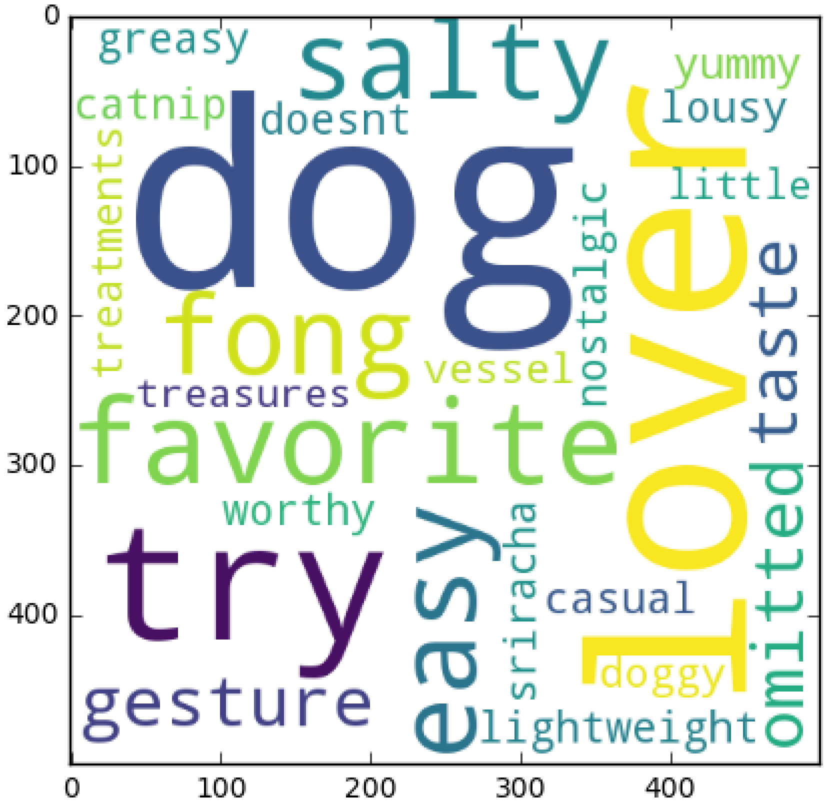
```
['doesnt taste', 'doggy', 'fong sriracha', 'treatments', 'casual', 'catnip',
'lovers try', 'nostalgic', 'treasures', 'lousy', 'dog lover', 'dogs little',
'omitted', 'greasy salty', 'dog favorite', 'easy yummy', 'lightweight', 'wor
thy', 'vessel', 'gesture'] ['glutamic acid', 'gluten flour', 'fred', 'brazil
ian', 'mitigate', 'nostalgic', 'cookie would', 'greasy salty', 'besides grea
t', 'past years', 'whatsoever', 'goo', 'best glad', 'flossies', 'tast', 'lig
htweight', 'gevalia signature', 'mak', 'celestial seasons', 'easy yummy']
['chocolat', 'nostalgic', 'darjeeling teas', 'dark brown', 'hot chili', 'hos
ting', 'banned', 'military', 'lightweight', 'coco', 'goo', 'besides great',
'tast', 'barry tea', 'cookie would', 'greasy salty', 'flavonoids', 'lousy',
'delicioso', 'sweep'] ['nostalgic', 'goo', 'lightweight', 'tast', 'greasy sa
lty', 'flavonoids', 'lousy', 'besides great', 'omitted', 'worthy', 'realizin
g', 'delicioso', 'nj', 'sufficiently', 'litters', 'usda organic', 'sweep',
'gesture', 'easy yummy', 'mak'] ['producing', 'greasy salty', 'amazingly tas
ty', 'prey', 'nostalgic', 'financial', 'shipper', 'goo', 'orchards', 'button
s', 'storage not', 'great problem', 'excellence', 'stored refrigerator', 'lo
usy', 'tim tams', 'grocers', 'lobster meat', 'worthy', 'besides great'] ['co
ffe', 'cumin', 'nostalgic', 'greasy salty', 'goo', 'flavonoids', 'stroller',
'cup cocoa', 'lightweight', 'roaring', 'boils', 'besides great', 'pod syste
m', 'great coconut', 'tast', 'espressione', 'omitted', 'sense smell', 'darje
eling teas', 'cuppa tea']
```

In [54]:

```
cl1_string = ' '.join(cl1)
cl2_string = ' '.join(cl2)
cl3_string = ' '.join(cl3)
cl4_string = ' '.join(cl4)
cl5_string = ' '.join(cl5)
cl6_string = ' '.join(cl6)
cl7_string = ' '.join(cl7)
```

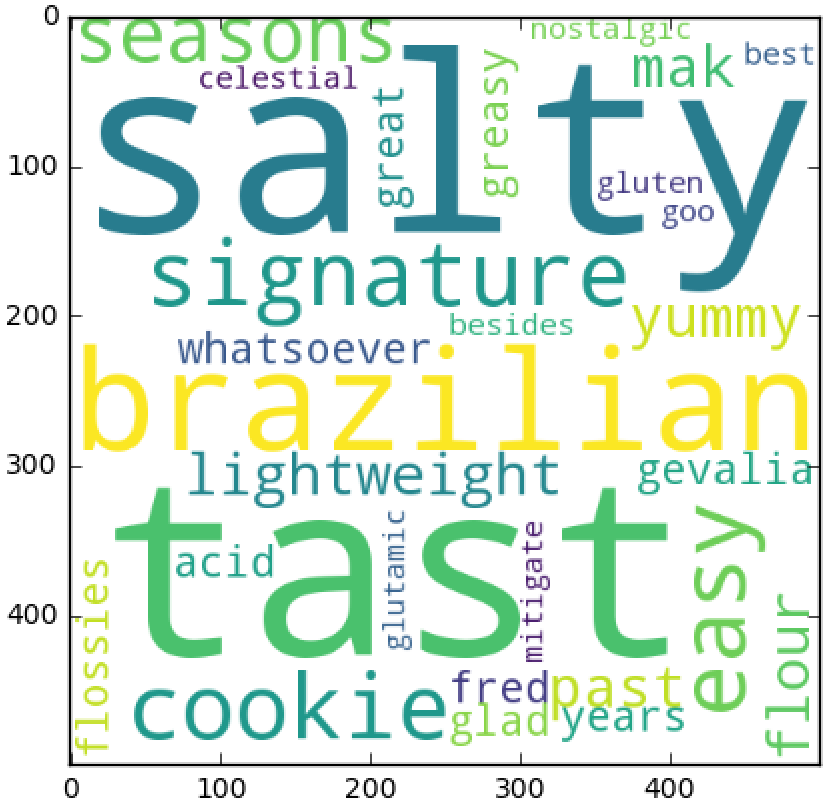
In [55]:

```
from wordcloud import WordCloud
wordcloud_cluster1 = WordCloud(width = 500, height = 500, background_color ='white').genera
wordcloud_cluster2 = WordCloud(width = 500, height = 500, background_color ='white').genera
wordcloud_cluster3 = WordCloud(width = 500, height = 500, background_color ='white').genera
wordcloud_cluster4 = WordCloud(width = 500, height = 500, background_color ='white').genera
wordcloud_cluster5 = WordCloud(width = 500, height = 500, background_color ='white').genera
wordcloud_cluster6 = WordCloud(width = 500, height = 500, background_color ='white').genera
wordcloud_cluster7 = WordCloud(width = 500, height = 500, background_color ='white').genera
# plot the WordCloud image
plt.imshow(wordcloud_cluster1)
plt.tight_layout(pad = 0)
plt.show()
```



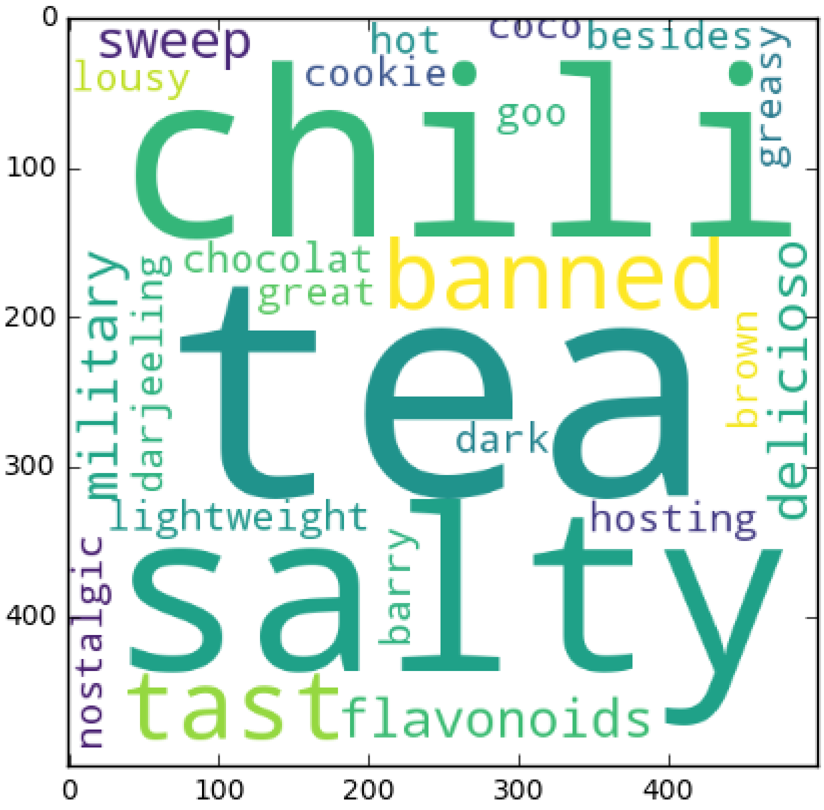
In [56]:

```
plt.imshow(wordcloud_cluster2)
plt.tight_layout(pad = 0)
plt.show()
```



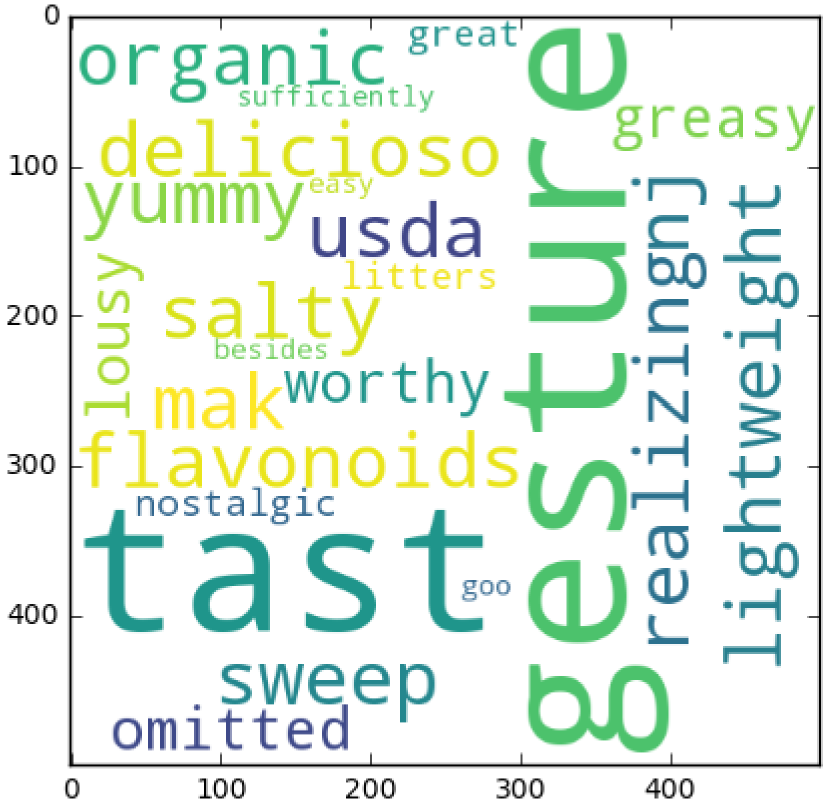
In [57]:

```
plt.imshow(wordcloud_cluster3)
plt.tight_layout(pad = 0)
plt.show()
```



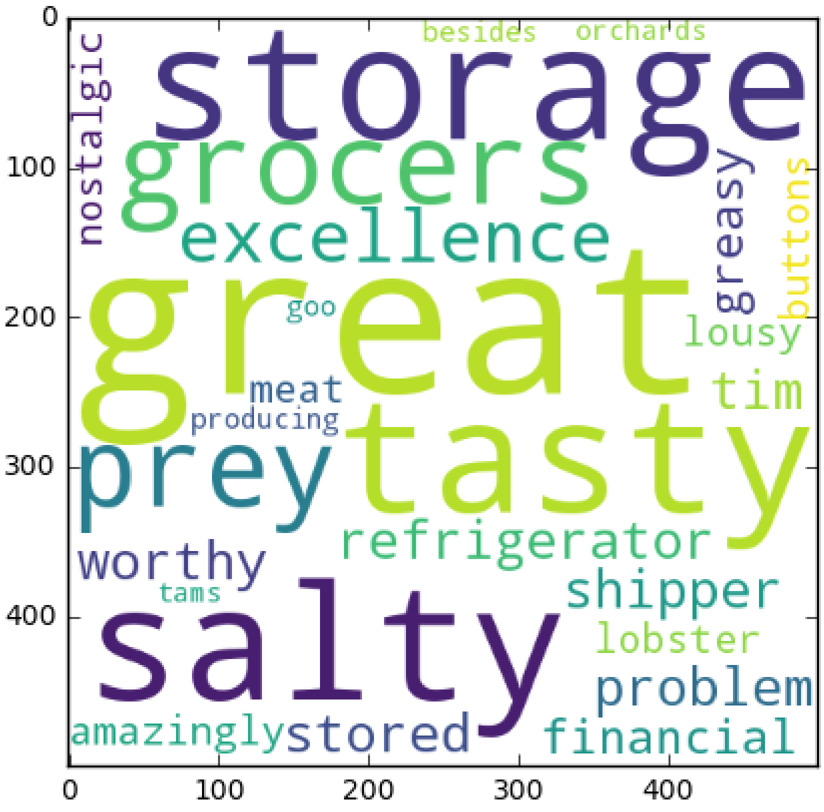
In [58]:

```
plt.imshow(wordcloud_cluster4)
plt.tight_layout(pad = 0)
plt.show()
```



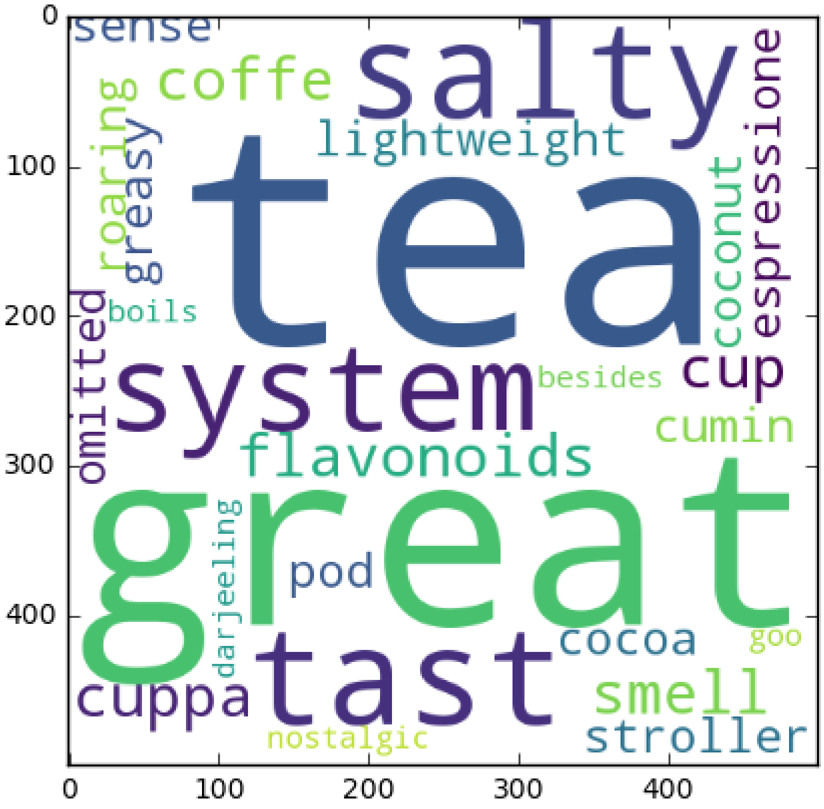
In [59]:

```
plt.imshow(wordcloud_cluster5)
plt.tight_layout(pad = 0)
plt.show()
```



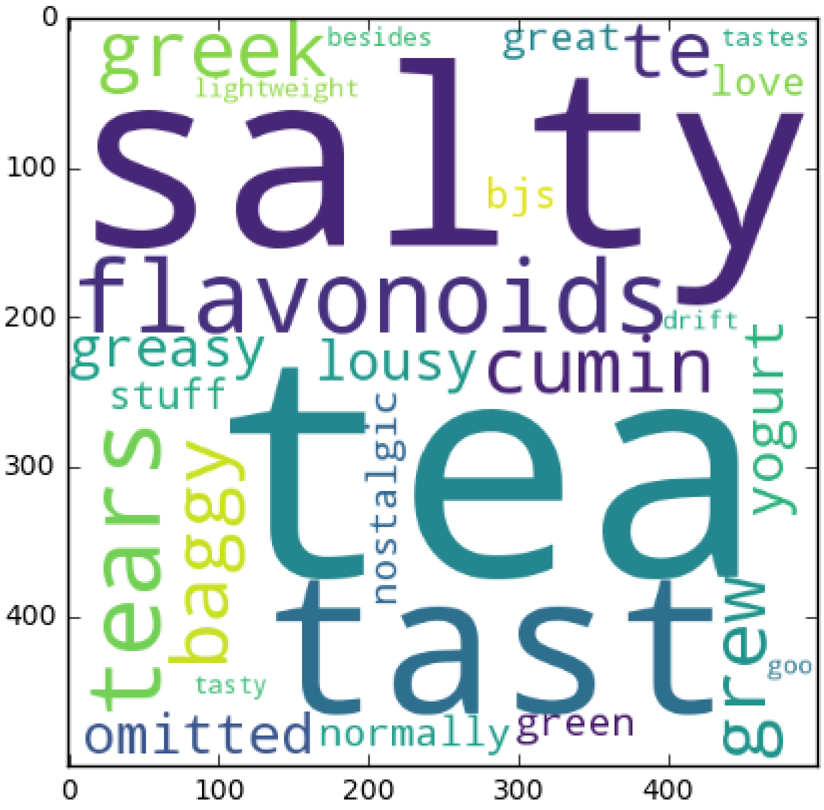
In [60]:

```
plt.imshow(wordcloud_cluster6)
plt.tight_layout(pad = 0)
plt.show()
```



In [61]:

```
plt.imshow(wordcloud_cluster7)
plt.tight_layout(pad = 0)
plt.show()
```



In [62]:

```
#function that takes a word and returns the most similar words using cosine similarity betw
def cosine_similarity(a,b):
    return dot(a,b) / ( (dot(a,a) **.5) * (dot(b,b) ** .5) )
```

Observations

cluster 1 represents related to dog food eg. dog, doggy, yummy
cluster 2 represents type of food eg. cookie, salty, brazilian
cluster 3 represents taste of food eg. salty, chili, sweet, coco
cluster 4 represents organic food eg. organic, great, worthy
cluster 5 represents shipping related information eg. shipping, financial, refregerator
cluster 6 represents taste of coffee eg. coffee, cocoa, smell, stronger
cluster 7 represents tea related information eg. tea, green, tasty