Class10_Candy_Analysis

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Table of contents

Background

Since it's close to Halloween, and the half way point in the quarter, let's do a mini project to help us figure out the best candy to buy

Our data come from 538 website and is available as a CSV file

Data import

First get the CSV file

```
url <- "https://raw.githubusercontent.com/fivethirtyeight/data/master/candy-power-ranking/ca

library("tidyverse")
```

```
-- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
v dplyr     1.1.4     v readr     2.1.5
v forcats   1.0.1     v stringr   1.5.2
v ggplot2   4.0.0     v tibble    3.3.0
```

```
v lubridate 1.9.4     v tidyr     1.3.1
v purrr     1.1.0
-- Conflicts ------------------------------------------ tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to becom
```

```
candy <- read_csv(url)
```

```
Rows: 85 Columns: 13
-- Column specification --------------------------------------------------------
Delimiter: ","
chr  (1): competitorname
dbl (12): chocolate, fruity, caramel, peanutyalmondy, nougat, crispedricewaf...

i Use `spec()` to retrieve the full column specification for this data.
i Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

```
flextable::flextable(head(candy,10))
```

competitorname	chocolate	fruity	caramel	peanutyalmondy	nougat	crispedricewafer	hard	bar
100 Grand	1	0	1	0	0	1	0	1
3 Musketeers	1	0	0	0	1	0	0	1
One dime	0	0	0	0	0	0	0	0
One quarter	0	0	0	0	0	0	0	0
Air Heads	0	1	0	0	0	0	0	0
Almond Joy	1	0	0	1	0	0	0	1
Baby Ruth	1	0	1	1	1	0	0	1
Boston Baked Beans	0	0	0	1	0	0	0	0
Candy Corn	0	0	0	0	0	0	0	0

competitorname	chocolate	fruity	caramel	peanutyalmondy	nougat	crispedricewafer	hard	bar
Caramel Apple Pops	0	1	1	0	0	0	0	0

> Q1. How many different candy types are in this dataset?

> A1: There are 85 candy types in this dataset

```
nrow(candy)
```

```
[1] 85
```

```
#OR we can also do (Require tydiverse)

candy |> # Note that `|>` is the same as `%>%`
  nrow()
```

```
[1] 85
```

> Q2. How many fruity candy types are in the dataset

> A2: There are 38 fruity types in the dataset

```
nrow(
  candy %>%
  filter(fruity == 1)
)
```

```
[1] 38
```

```
head (
  candy %>%
  filter(fruity == 1)
)
```

```
# A tibble: 6 x 13
  competitorname chocolate fruity caramel peanutyalmondy nougat crispedricewafer
  <chr>              <dbl>  <dbl>   <dbl>          <dbl>  <dbl>            <dbl>
1 Air Heads              0      1       0              0      0                0
2 Caramel Apple~         0      1       1              0      0                0
3 Chewey Lemonh~         0      1       0              0      0                0
4 Chiclets               0      1       0              0      0                0
5 Dots                   0      1       0              0      0                0
6 Dum Dums               0      1       0              0      0                0
# i 6 more variables: hard <dbl>, bar <dbl>, pluribus <dbl>,
#   sugarpercent <dbl>, pricepercent <dbl>, winpercent <dbl>
```

What is your favorite candy?

To access the win percent of a candy use the following code

```
library(dplyr)
candy %>%
  filter(competitorname == "Twix") %>%
  select(winpercent)
```

```
# A tibble: 1 x 1
  winpercent
       <dbl>
1       81.6
```

```
candy_winpercent <- function(x){
  candy %>%
  filter(competitorname == x) %>%
  select(winpercent)
}
```

> Q3. What is your favorite candy in the dataset and what is it’s winpercent value?
>
> A3: Its haribro happy cola , win rate is 34.158958
>
> Q4. What is the winpercent value for “Kit Kat”?
>
> A4:win rate is 76.7686
>
> Q5. What is the winpercent value for “Tootsie Roll Snack Bars”?
>
> A4:win rate is 49.653503

quick overview of dataset

Using the skim function to skim the dataset

```r
skimr::skim(candy)
```

Table 2: Data summary

Name	candy
Number of rows	85
Number of columns	13
Column type frequency:	
character	1
numeric	12
Group variables	None

Variable type: character

skim_variable	n_missing	complete_rate	min	max	empty	n_unique	whitespace
competitorname	0	1	4	27	0	85	0

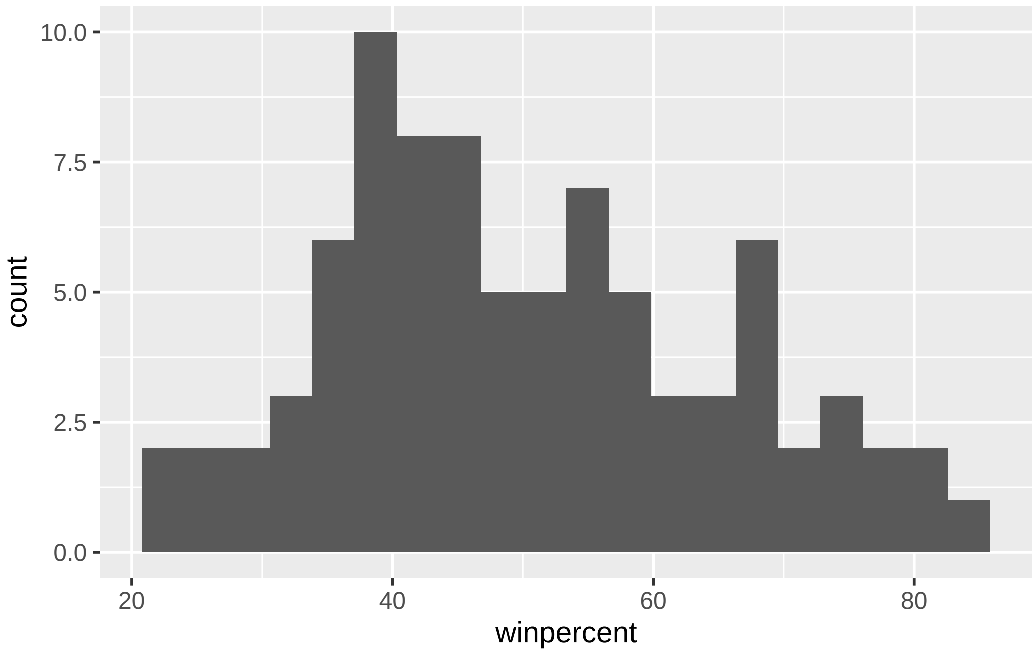
Variable type: numeric

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
chocolate	0	1	0.44	0.50	0.00	0.00	0.00	1.00	1.00	
fruity	0	1	0.45	0.50	0.00	0.00	0.00	1.00	1.00	
caramel	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
peanutyalmondy	0	1	0.16	0.37	0.00	0.00	0.00	0.00	1.00	
nougat	0	1	0.08	0.28	0.00	0.00	0.00	0.00	1.00	
crispedricewafer	0	1	0.08	0.28	0.00	0.00	0.00	0.00	1.00	
hard	0	1	0.18	0.38	0.00	0.00	0.00	0.00	1.00	
bar	0	1	0.25	0.43	0.00	0.00	0.00	0.00	1.00	
pluribus	0	1	0.52	0.50	0.00	0.00	1.00	1.00	1.00	
sugarpercent	0	1	0.48	0.28	0.01	0.22	0.47	0.73	0.99	
pricepercent	0	1	0.47	0.29	0.01	0.26	0.47	0.65	0.98	
winpercent	0	1	50.32	14.71	22.45	39.14	47.83	59.86	84.18	

Note that from the skim function we can see that the variance within the winpercent variable is very large (remeber to scale this value prior to our PCA analysis)

> Q6:Is there any variable/column that looks to be on a different scale to the majority of the other columns in the dataset?
>
> A6: The winpercent is on a 0-100 scale and the rest are 0-1 scale
>
> Q7:What do you think a zero and one represent for the candy$chocolate column?
>
> A7: That the candy does not have chocolate in it
>
> Q8:Plot a histogram of winpercent values

```
library(ggplot2)
ggplot(candy,aes(x=winpercent))+
  geom_histogram(bins=20)
```



> Q9. Is the distribution of winpercent values symmetrical?
>
> A9: It is not symmetrical
>
> Q10: Is the center of the distribution above or below 50%?

A10: We can see the peak is clearly below 50, but the mean is 50.3167638 so we can use median to represent this distribution, which is 47.83

```
summary(candy$winpercent)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max. 
  22.45   39.14   47.83   50.32   59.86   84.18 
```

Q11. On average is chocolate candy higher or lower ranked than fruit candy?

```
#1. Find all chocolate candy in the dataset
#2. Find their winpercent value
#3. calculate the mean of these winpercent
#4. repeat the above steps for fruity candy and compare

Choco.inds <- candy$chocolate==1
Choco.win <- candy[Choco.inds,]$winpercent
Choco.mean <- mean(Choco.win)
Choco.mean
```

```
[1] 60.92153
```

```
fru.inds <- candy$fruity==1
fru.win <- candy[fru.inds,]$winpercent
fru.mean <- mean(fru.win)
fru.mean
```

```
[1] 44.11974
```

```
#OR We can do

candy_chocolate <- candy %>%
  filter(chocolate == 1) %>%
  select(winpercent)

mean(candy_chocolate$winpercent)
```

```
[1] 60.92153
```

```r
candy_fruity <- candy %>%
  filter(fruity == 1) %>%
  select(winpercent)

mean(candy_fruity$winpercent)
```

```
[1] 44.11974
```

> A11: On average, the mean win percentage of chocolate candy is 60.9215294 while the mean win percentage of fruity candy is 44.1197414

> Q12: Is this difference significant?

> A12: we are gonna use the ttest function. Yes, the difference is significant (p-value = 2.871e-08)

```r
t.test(Choco.win, fru.win)
```

```

	Welch Two Sample t-test

data:  Choco.win and fru.win
t = 6.2582, df = 68.882, p-value = 2.871e-08
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 11.44563 22.15795
sample estimates:
mean of x mean of y 
 60.92153  44.11974 
```

Candy Ranking

> Q13. What are the five least liked candy types in this set?

> A13: They are Snickers, Kit Kat, Twix, Reese's Miniatures, Reese's Peanut Butter cup

```r
x <- c(5,1,3,4)
sort(x)
```

```
[1] 1 3 4 5
```

```r
order(x) # gives the position of the numbers in the order
```

```
[1] 2 3 4 1
```

```r
ord.ind <- order(candy$winpercent)
head(candy[ord.ind,],5)
```

```
# A tibble: 5 x 13
  competitorname chocolate fruity caramel peanutyalmondy nougat crispedricewafer
  <chr>              <dbl>  <dbl>   <dbl>          <dbl>  <dbl>            <dbl>
1 Nik L Nip              0      1       0              0      0                0
2 Boston Baked ~         0      0       0              1      0                0
3 Chiclets               0      1       0              0      0                0
4 Super Bubble           0      1       0              0      0                0
5 Jawbusters             0      1       0              0      0                0
# i 6 more variables: hard <dbl>, bar <dbl>, pluribus <dbl>,
#   sugarpercent <dbl>, pricepercent <dbl>, winpercent <dbl>
```

```r
#If we write everything in one line, we get:
tail(candy[order(candy$winpercent),], n=5)
```

```
# A tibble: 5 x 13
  competitorname chocolate fruity caramel peanutyalmondy nougat crispedricewafer
  <chr>              <dbl>  <dbl>   <dbl>          <dbl>  <dbl>            <dbl>
1 Snickers               1      0       1              1      1                0
2 Kit Kat                1      0       0              0      0                1
3 Twix                   1      0       1              0      0                1
4 Reese's Minia~         1      0       0              1      0                0
5 Reese's Peanu~         1      0       0              1      0                0
# i 6 more variables: hard <dbl>, bar <dbl>, pluribus <dbl>,
#   sugarpercent <dbl>, pricepercent <dbl>, winpercent <dbl>
```

```r
#OR WE CAN DO
candy %>%
  arrange(desc(winpercent)) %>%
  head(5)
```

```
# A tibble: 5 x 13
  competitorname chocolate fruity caramel peanutyalmondy nougat crispedricewafer
  <chr>                <dbl>  <dbl>   <dbl>            <dbl>  <dbl>            <dbl>
1 Reese's Peanu~           1      0       0                1      0                0
2 Reese's Minia~           1      0       0                1      0                0
3 Twix                     1      0       1                0      0                1
4 Kit Kat                  1      0       0                0      0                1
5 Snickers                 1      0       1                1      1                0
# i 6 more variables: hard <dbl>, bar <dbl>, pluribus <dbl>,
#   sugarpercent <dbl>, pricepercent <dbl>, winpercent <dbl>
```

Q14. What are the top 5 all time favorite candy types out of this set?

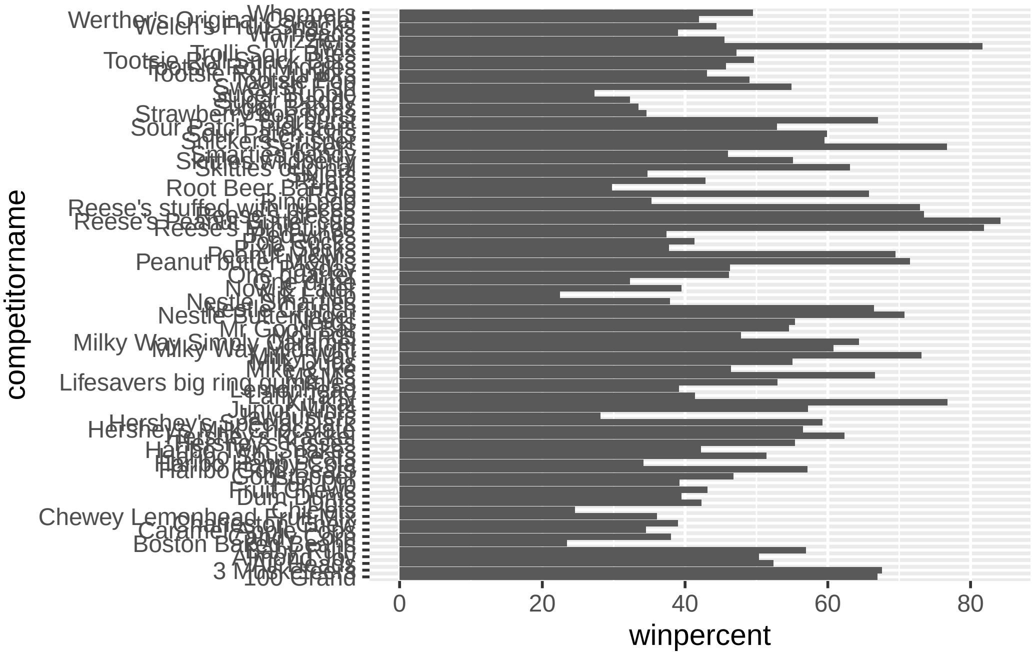
A14: They are Nik L Nip, Boston Baked Beans, Chiclets, Super Bubble, Jawbusters

```
candy %>%
  arrange(winpercent) %>%
  head(5)
```

```
# A tibble: 5 x 13
  competitorname chocolate fruity caramel peanutyalmondy nougat crispedricewafer
  <chr>                <dbl>  <dbl>   <dbl>            <dbl>  <dbl>            <dbl>
1 Nik L Nip                0      1       0                0      0                0
2 Boston Baked ~           0      0       0                1      0                0
3 Chiclets                 0      1       0                0      0                0
4 Super Bubble             0      1       0                0      0                0
5 Jawbusters               0      1       0                0      0                0
# i 6 more variables: hard <dbl>, bar <dbl>, pluribus <dbl>,
#   sugarpercent <dbl>, pricepercent <dbl>, winpercent <dbl>
```

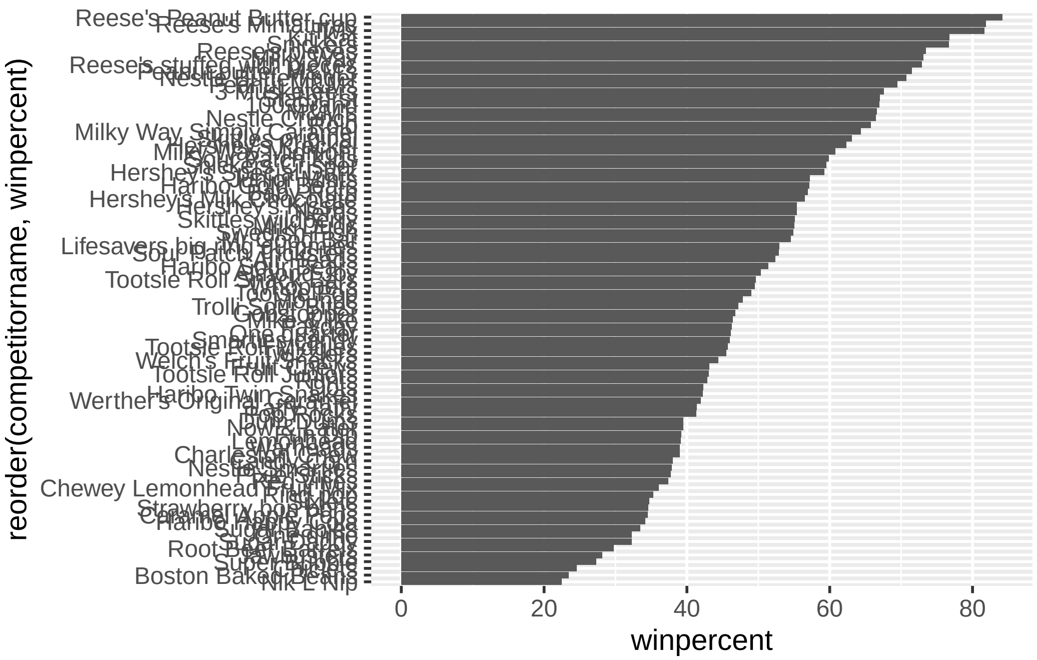
Q15. Make a first barplot of candy ranking based on winpercent values.

```
ggplot(candy, aes(y=competitorname,x=winpercent))+
  geom_col()
```



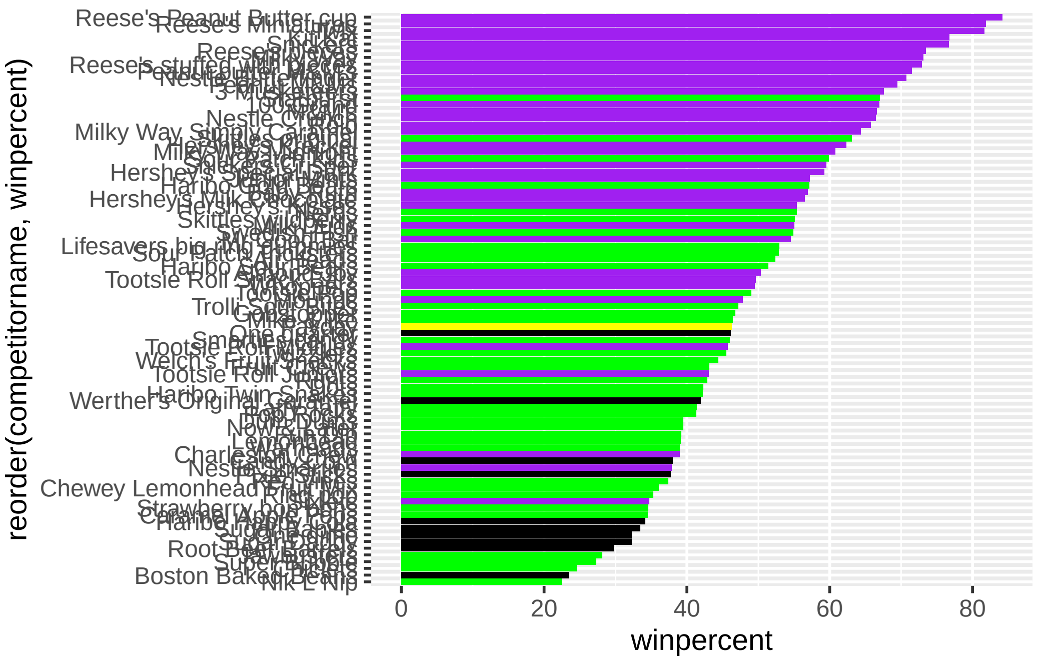
Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent?

```
ggplot(candy, aes(y=reorder(competitorname,winpercent),x=winpercent))+
  geom_col()
```



Time to add some useful color

```
my_cols=rep("black", nrow(candy))
my_cols[as.logical(candy$bar)] = "yellow"
my_cols[as.logical(candy$chocolate)] = "purple"
#Note that in this code, if we have a chocolate bar, its gonna get colored yellow first, then
my_cols[as.logical(candy$fruity)] = "green"
ggplot(candy) +
  aes(winpercent, reorder(competitorname,winpercent)) +
  geom_col(fill=my_cols)
```



Now, for the first time, using this plot we can answer questions like: >Q17. What is the worst ranked chocolate candy?

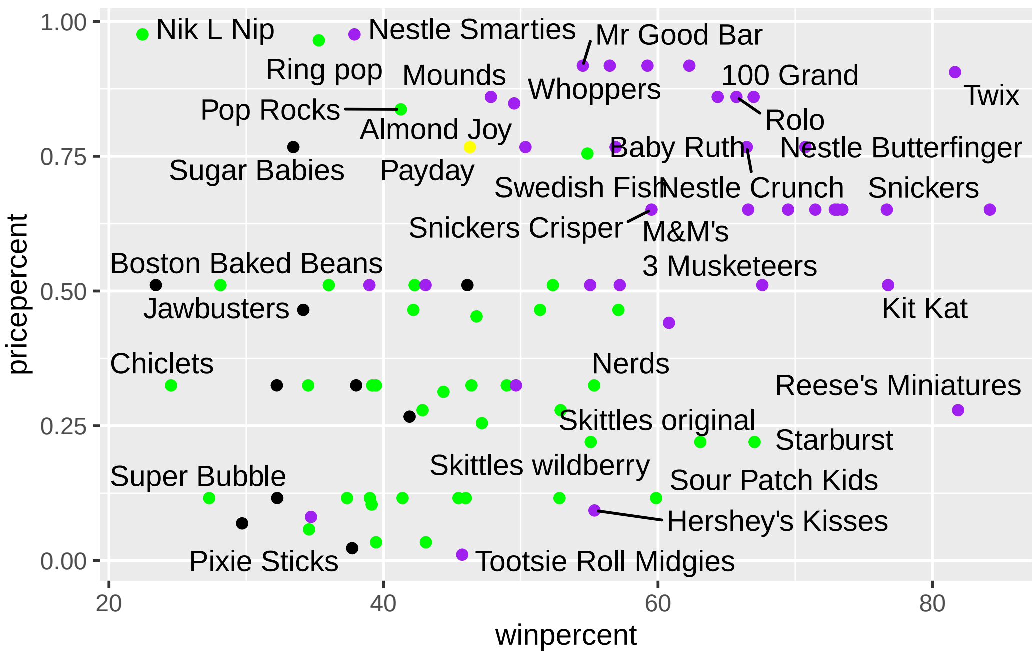
> A17: sixlet
>
> Q18. What is the best ranked fruity candy?
>
> A18: starbust

Winpercent and Pricepercent

Now let's plot the winpercent and the price percent at the same time

```
library(ggrepel)
ggplot(candy, aes(x = winpercent, y = pricepercent, label = competitorname))+
  geom_point(col=my_cols)+
  geom_text_repel()
```

```
Warning: ggrepel: 50 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



We can see that chocolate candy tends to be more expensive, and the fruity one is less expensive and less popular

> Q19. Which candy type is the highest ranked in terms of winpercent for the least money - i.e. offers the most bang for your buck?

> A19: Tootsie Roll Midgies

```
candy$price_win_ratio <- candy$winpercent / candy$pricepercent
best <- candy[which.max(candy$price_win_ratio), ]
best
```

```
# A tibble: 1 x 14
  competitorname chocolate fruity caramel peanutyalmondy nougat crispedricewafer
  <chr>                <dbl>  <dbl>   <dbl>          <dbl>  <dbl>            <dbl>
1 Tootsie Roll ~           1      0       0              0      0                0
# i 7 more variables: hard <dbl>, bar <dbl>, pluribus <dbl>,
#   sugarpercent <dbl>, pricepercent <dbl>, winpercent <dbl>,
#   price_win_ratio <dbl>
```

> Q20. What are the top 5 most expensive candy types in the dataset and of these which is the least popular?

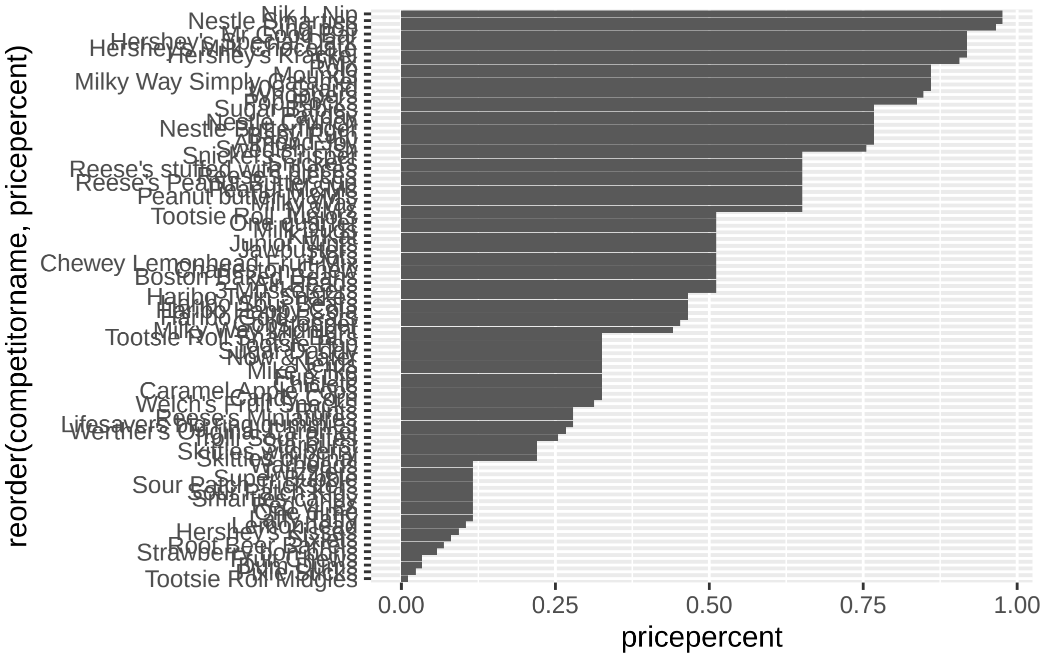
A20: The top 5 most expensive candy type are NiK L Nip, Nestle Smarties, Ring pop, Hersheys Krackel, and Hersheys Milk Chocolate. Of these the least popular is the Nik L Nip

```
ord <- order(candy$pricepercent, decreasing = TRUE)
head( candy[ord,c(11,12)], n=5 )
```

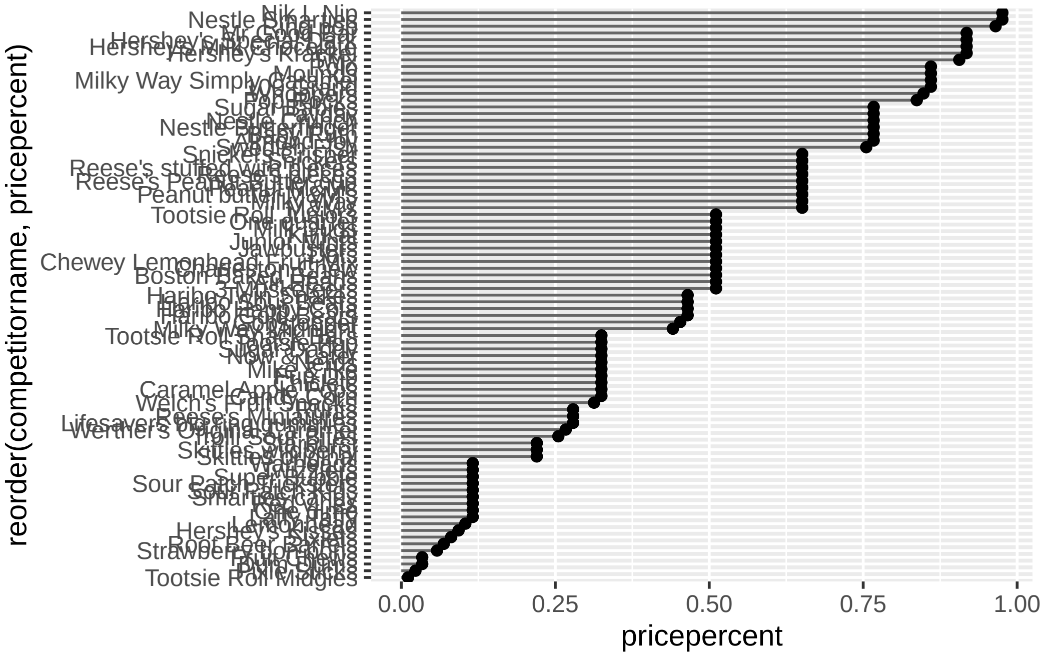
```
# A tibble: 5 x 2
  sugarpercent pricepercent
         <dbl>        <dbl>
1        0.197        0.976
2        0.267        0.976
3        0.732        0.965
4        0.430        0.918
5        0.430        0.918
```

Q21. Make a barplot again with geom_col() this time using pricepercent and then improve this step by step, first ordering the x-axis by value and finally making a so called "dot chat" or "lollipop" chart by swapping geom_col() for geom_point() + geom_segment().

```
ggplot(candy, aes(y=reorder(competitorname,pricepercent),x=pricepercent))+
  geom_col()
```



```
# Make a lollipop chart of pricepercent
ggplot(candy) +
  aes(pricepercent, reorder(competitorname, pricepercent)) +
  geom_segment(aes(yend = reorder(competitorname, pricepercent),
                   xend = 0), col="gray40") +
    geom_point()
```



Exploring the correlation structure

Now we are gonna try to calculate the correlation between all of the columns of our dataset

```
library(corrplot)
```

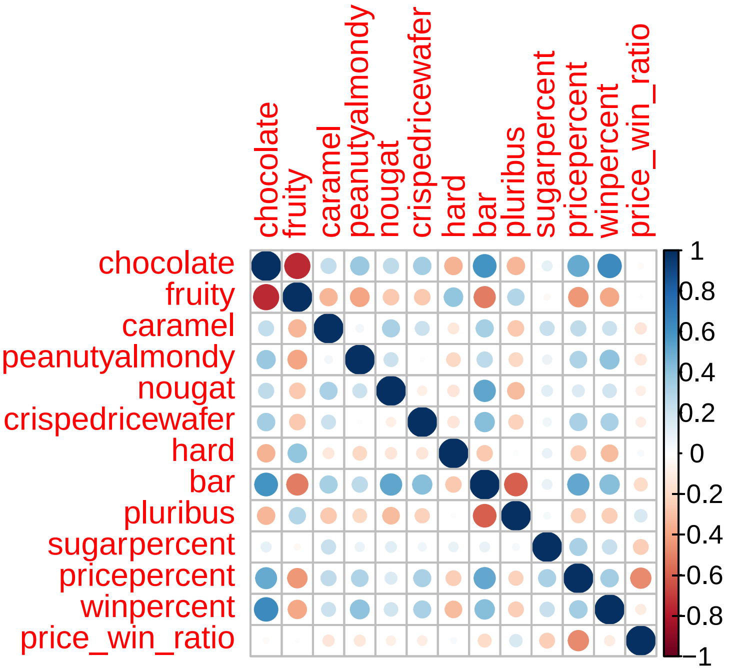
```
corrplot 0.95 loaded
```

```
cij <- cor(candy[,-1])
cij
```

```
                  chocolate      fruity     caramel peanutyalmondy      nougat
chocolate        1.00000000 -0.74172106  0.24987535     0.37782357  0.25489183
```

```
fruity           -0.74172106  1.00000000 -0.33548538    -0.39928014 -0.26936712
caramel           0.24987535 -0.33548538  1.00000000     0.05935614  0.32849280
peanutyalmondy    0.37782357 -0.39928014  0.05935614     1.00000000  0.21311310
nougat            0.25489183 -0.26936712  0.32849280     0.21311310  1.00000000
crispedricewafer  0.34120978 -0.26936712  0.21311310    -0.01764631 -0.08974359
hard             -0.34417691  0.39067750 -0.12235513    -0.20555661 -0.13867505
bar               0.59742114 -0.51506558  0.33396002     0.26041960  0.52297636
pluribus         -0.33967519  0.29972522 -0.26958501    -0.20610932 -0.31033884
sugarpercent      0.10416906 -0.03439296  0.22193335     0.08788927  0.12308135
pricepercent      0.50467535 -0.43096853  0.25432709     0.30915323  0.15319643
winpercent        0.63651675 -0.38093814  0.21341630     0.40619220  0.19937530
price_win_ratio  -0.02971799  0.01128280 -0.13556801    -0.12892537 -0.08906992
                 crispedricewafer        hard         bar    pluribus
chocolate              0.34120978 -0.34417691  0.59742114 -0.33967519
fruity                -0.26936712  0.39067750 -0.51506558  0.29972522
caramel                0.21311310 -0.12235513  0.33396002 -0.26958501
peanutyalmondy        -0.01764631 -0.20555661  0.26041960 -0.20610932
nougat                -0.08974359 -0.13867505  0.52297636 -0.31033884
crispedricewafer       1.00000000 -0.13867505  0.42375093 -0.22469338
hard                  -0.13867505  1.00000000 -0.26516504  0.01453172
bar                    0.42375093 -0.26516504  1.00000000 -0.59340892
pluribus              -0.22469338  0.01453172 -0.59340892  1.00000000
sugarpercent           0.06994969  0.09180975  0.09998516  0.04552282
pricepercent           0.32826539 -0.24436534  0.51840654 -0.22079363
winpercent             0.32467965 -0.31038158  0.42992933 -0.24744787
price_win_ratio       -0.09666726  0.03379455 -0.18297628  0.16685463
                 sugarpercent pricepercent winpercent price_win_ratio
chocolate          0.10416906    0.5046754  0.6365167     -0.02971799
fruity            -0.03439296   -0.4309685 -0.3809381      0.01128280
caramel            0.22193335    0.2543271  0.2134163     -0.13556801
peanutyalmondy     0.08788927    0.3091532  0.4061922     -0.12892537
nougat             0.12308135    0.1531964  0.1993753     -0.08906992
crispedricewafer   0.06994969    0.3282654  0.3246797     -0.09666726
hard               0.09180975   -0.2443653 -0.3103816      0.03379455
bar                0.09998516    0.5184065  0.4299293     -0.18297628
pluribus           0.04552282   -0.2207936 -0.2474479      0.16685463
sugarpercent       1.00000000    0.3297064  0.2291507     -0.24406690
pricepercent       0.32970639    1.0000000  0.3453254     -0.47180948
winpercent         0.22915066    0.3453254  1.0000000     -0.10863087
price_win_ratio   -0.24406690   -0.4718095 -0.1086309      1.00000000
```

```r
corrplot(cij)
```



Q22. Examining this plot what two variables are anti-correlated (i.e. have minus values)?

A22: Chocolate and fruity, because if a candy is chocolate it is made of chocolate and not fruit.

Q23. Similarly, what two variables are most positively correlated?

A23: Chocolate and price & chocolate and bar

PCA

Recall function to use here is `prcomp` with the optional scale argument

```r
pca <- prcomp(candy[,-1],scale=TRUE)
summary(pca)
```

```
Importance of components:
                          PC1    PC2     PC3    PC4     PC5     PC6     PC7
Standard deviation     2.0938 1.2127 1.13054 1.0787 0.98027 0.93656 0.81530
```

```
Proportion of Variance 0.3372 0.1131 0.09832 0.0895 0.07392 0.06747 0.05113
Cumulative Proportion  0.3372 0.4503 0.54866 0.6382 0.71208 0.77956 0.83069
                           PC8     PC9    PC10    PC11    PC12    PC13
Standard deviation     0.78462 0.68466 0.66328 0.57829 0.43128 0.39534
Proportion of Variance 0.04736 0.03606 0.03384 0.02572 0.01431 0.01202
Cumulative Proportion  0.87804 0.91410 0.94794 0.97367 0.98798 1.00000
```

```
pca
```

```
Standard deviations (1, .., p=13):
 [1] 2.0937535 1.2127184 1.1305394 1.0786777 0.9802705 0.9365644 0.8153036
 [8] 0.7846165 0.6846599 0.6632822 0.5782857 0.4312832 0.3953445

Rotation (n x k) = (13 x 13):
                        PC1          PC2         PC3           PC4         PC5
chocolate        -0.3924439 -0.219448144  0.15058469 -0.0114250051 -0.07105041
fruity            0.3588085  0.265751128 -0.06419261 -0.0414216903  0.10444609
caramel          -0.2293954  0.185201638 -0.29188009 -0.1131639560 -0.51223340
peanutyalmondy   -0.2389173 -0.112739803  0.13689124  0.5237380179  0.27665942
nougat           -0.2241826  0.022531785 -0.55962535  0.3358934505 -0.14260284
crispedricewafer -0.2195121  0.039093933  0.22057443 -0.6773790754 -0.03722188
hard              0.2059573  0.320563450 -0.26209629 -0.1224691573  0.06236033
bar              -0.3912663 -0.004827650 -0.25701611 -0.1634667675  0.12009145
pluribus          0.2590791 -0.002370332  0.46082634  0.2144772981 -0.38079984
sugarpercent     -0.1161206  0.548733387  0.16560684  0.2005637175 -0.46041761
pricepercent     -0.3299041  0.311975067  0.25547945 -0.0007214477  0.16401024
winpercent       -0.3250778 -0.075548141  0.24143214  0.0768869968 -0.11815717
price_win_ratio   0.1359085 -0.570297097 -0.09663968 -0.0743019060 -0.45522982
                          PC6           PC7         PC8          PC9
chocolate         0.168012098 -0.0820264438 -0.22902045 -0.356733735
fruity            0.070137283  0.4628654891  0.27452454  0.094856568
caramel          -0.244254122 -0.4325648105  0.48368965  0.006498170
peanutyalmondy    0.283589046 -0.2543683871  0.30643273  0.537530170
nougat           -0.132132306  0.3641241953 -0.19720243  0.245456190
crispedricewafer  0.080758716  0.1328929581  0.09283457  0.530877726
hard              0.660819574 -0.3168714332 -0.18487010  0.009347836
bar              -0.003492824  0.2356475753 -0.24112853  0.147918692
pluribus         -0.219240043  0.0395262256 -0.20700502  0.282258901
sugarpercent      0.267637811  0.1460393254 -0.16224957 -0.007795535
pricepercent     -0.166682572 -0.1579120355 -0.34578465  0.047548219
winpercent        0.333724015  0.4161740441  0.42330437 -0.307143205
price_win_ratio   0.327480160 -0.0007099284 -0.19123968  0.185435980
```

```
                        PC10        PC11        PC12        PC13
chocolate         0.204343511  0.03055033  0.04150283  0.71477134
fruity           -0.010883670 -0.48239113  0.05817828  0.49412325
caramel           0.096671412 -0.21146289  0.10638886  0.08089608
peanutyalmondy   -0.089075185 -0.01744526  0.08152461  0.13332819
nougat            0.297846590  0.13181443 -0.38006014  0.05637103
crispedricewafer  0.081590021  0.24987963 -0.21829437  0.10012004
hard              0.429260577 -0.02949363  0.03199238 -0.09862215
bar              -0.057997495 -0.16266859  0.74322586 -0.14802838
pluribus          0.517349972 -0.02681627  0.29738048 -0.02339919
sugarpercent     -0.478913585  0.22932098  0.04480374  0.04974921
pricepercent     -0.002069487 -0.62192962 -0.34680471 -0.14157619
winpercent        0.289101852 -0.12797561 -0.06613302 -0.38474323
price_win_ratio  -0.277946525 -0.39713642 -0.12779672 -0.06847945
```

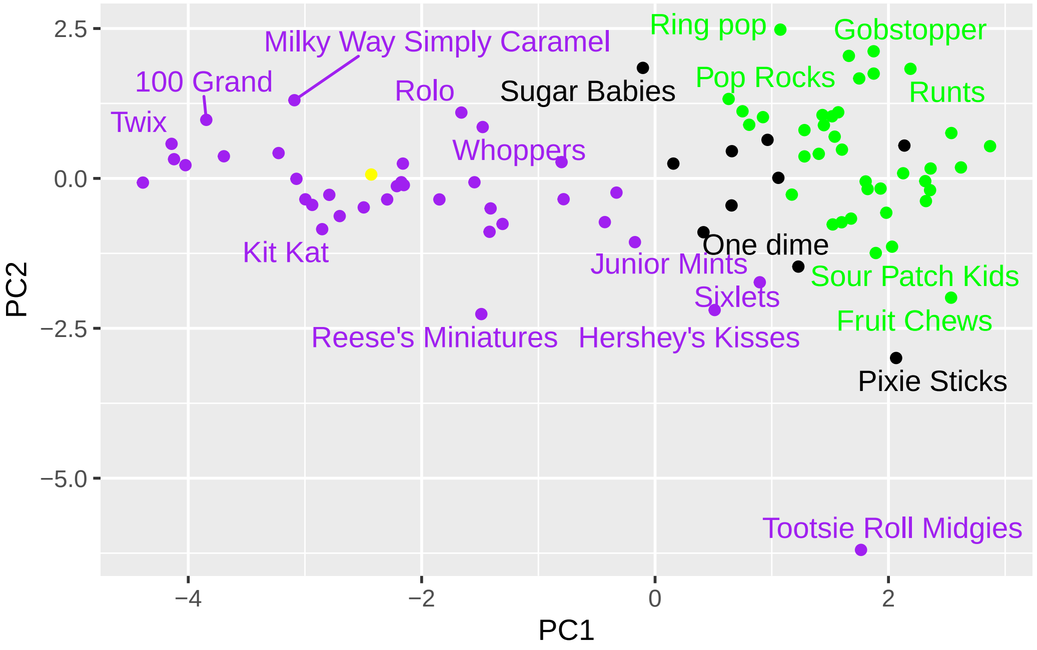
Our main PCA result figure

```r
pca <- prcomp(select(candy, where(is.numeric)), scale. = TRUE)

pca_scores <- as.data.frame(pca$x) %>%
  mutate(competitorname = candy$competitorname)

# Plot
ggplot(pca_scores, aes(x = PC1, y = PC2, label = competitorname)) +
  geom_point(color = my_cols) +
  geom_text_repel(color = my_cols)
```

```
Warning: ggrepel: 65 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```



We can see separation of fruity candy (green) vs chocolate candy (purple)

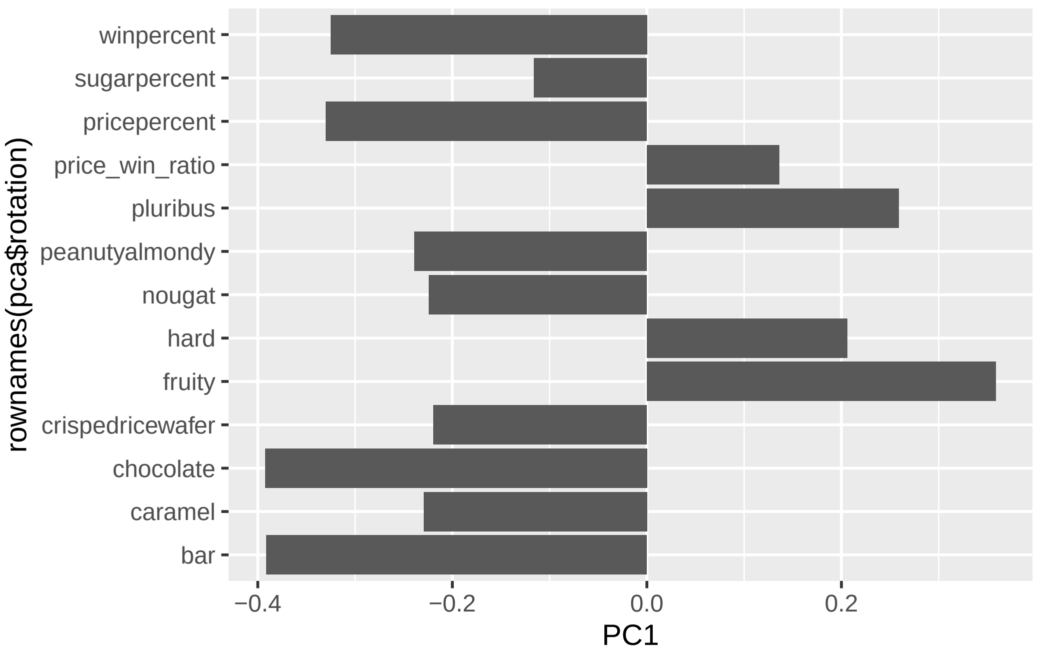
we should examine the variable "loadings" or contribution

```
pca$rotation
```

```
                        PC1          PC2         PC3           PC4         PC5
chocolate        -0.3924439 -0.219448144  0.15058469 -0.0114250051 -0.07105041
fruity            0.3588085  0.265751128 -0.06419261 -0.0414216903  0.10444609
caramel          -0.2293954  0.185201638 -0.29188009 -0.1131639560 -0.51223340
peanutyalmondy   -0.2389173 -0.112739803  0.13689124  0.5237380179  0.27665942
nougat           -0.2241826  0.022531785 -0.55962535  0.3358934505 -0.14260284
crispedricewafer -0.2195121  0.039093933  0.22057443 -0.6773790754 -0.03722188
hard              0.2059573  0.320563450 -0.26209629 -0.1224691573  0.06236033
bar              -0.3912663 -0.004827650 -0.25701611 -0.1634667675  0.12009145
pluribus          0.2590791 -0.002370332  0.46082634  0.2144772981 -0.38079984
sugarpercent     -0.1161206  0.548733387  0.16560684  0.2005637175 -0.46041761
pricepercent     -0.3299041  0.311975067  0.25547945 -0.0007214477  0.16401024
winpercent       -0.3250778 -0.075548141  0.24143214  0.0768869968 -0.11815717
price_win_ratio   0.1359085 -0.570297097 -0.09663968 -0.0743019060 -0.45522982
                         PC6           PC7         PC8          PC9
chocolate         0.168012098 -0.0820264438 -0.22902045 -0.356733735
fruity            0.070137283  0.4628654891  0.27452454  0.094856568
```

```
caramel          -0.244254122 -0.4325648105  0.48368965  0.006498170
peanutyalmondy    0.283589046 -0.2543683871  0.30643273  0.537530170
nougat           -0.132132306  0.3641241953 -0.19720243  0.245456190
crispedricewafer  0.080758716  0.1328929581  0.09283457  0.530877726
hard              0.660819574 -0.3168714332 -0.18487010  0.009347836
bar              -0.003492824  0.2356475753 -0.24112853  0.147918692
pluribus         -0.219240043  0.0395262256 -0.20700502  0.282258901
sugarpercent      0.267637811  0.1460393254 -0.16224957 -0.007795535
pricepercent     -0.166682572 -0.1579120355 -0.34578465  0.047548219
winpercent        0.333724015  0.4161740441  0.42330437 -0.307143205
price_win_ratio   0.327480160 -0.0007099284 -0.19123968  0.185435980
                         PC10        PC11        PC12        PC13
chocolate         0.204343511  0.03055033  0.04150283  0.71477134
fruity           -0.010883670 -0.48239113  0.05817828  0.49412325
caramel           0.096671412 -0.21146289  0.10638886  0.08089608
peanutyalmondy   -0.089075185 -0.01744526  0.08152461  0.13332819
nougat            0.297846590  0.13181443 -0.38006014  0.05637103
crispedricewafer  0.081590021  0.24987963 -0.21829437  0.10012004
hard              0.429260577 -0.02949363  0.03199238 -0.09862215
bar              -0.057997495 -0.16266859  0.74322586 -0.14802838
pluribus          0.517349972 -0.02681627  0.29738048 -0.02339919
sugarpercent     -0.478913585  0.22932098  0.04480374  0.04974921
pricepercent     -0.002069487 -0.62192962 -0.34680471 -0.14157619
winpercent        0.289101852 -0.12797561 -0.06613302 -0.38474323
price_win_ratio  -0.277946525 -0.39713642 -0.12779672 -0.06847945
```

```
ggplot(pca$rotation,aes(PC1,rownames(pca$rotation)))+
  geom_col()
```



Q24. What original variables are picked up strongly by PC1 in the positive direction? Do these make sense to you?

A24: Fruity, hard, pluribus are picked up by PC1. This makese sense because they all describe the fruity candy, so if they all picked up by PC1 in the positive direction, it would allow us to group the fruity candy in a cluster.