Class 9: Candy Analysis Mini Project

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In today's class we will examine some data about candy from the 538 website.

Import Data

```
candy_file <- "candy-data.txt"

candy = read.csv(candy_file, row.names=1)
head(candy)
```

```
             chocolate fruity caramel peanutyalmondy nougat crispedricewafer
100 Grand            1      0       1              0      0                 1
3 Musketeers         1      0       0              0      1                 0
One dime             0      0       0              0      0                 0
One quarter          0      0       0              0      0                 0
Air Heads            0      1       0              0      0                 0
Almond Joy           1      0       0              1      0                 0
             hard bar pluribus sugarpercent pricepercent winpercent
100 Grand       0   1        0        0.732        0.860   66.97173
3 Musketeers    0   1        0        0.604        0.511   67.60294
One dime        0   0        0        0.011        0.116   32.26109
One quarter     0   0        0        0.011        0.511   46.11650
Air Heads       0   0        0        0.906        0.511   52.34146
Almond Joy      0   1        0        0.465        0.767   50.34755
```

Data Exploration

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

```
nrow(candy)
```

```
[1] 85
```

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

```
sum(candy$fruit)
```

```
[1] 38
```

> Q3. What is your favorite candy in the dataset and what is it's winpercent value?

My favorite candy is Reese's Peanut Butter Cups, with a winpercent of 84.18029%.

```
candy["Reese's Peanut Butter cup", ]$winpercent
```

```
[1] 84.18029
```

> Q4. What is the winpercent value for "Kit Kat"?

```
candy["Kit Kat", ]$winpercent
```

```
[1] 76.7686
```

> Q5. What is the winpercent value for "Tootsie Roll Snack Bars"?

```
candy["Tootsie Roll Snack Bars", ]$winpercent
```

```
[1] 49.6535
```

> Q6. Is there any variable/column that looks to be on a different scale to the majority of the other columns in the dataset?

```
library("skimr")
skimr::skim(candy)
```

Data summary

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

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	▇▁▁▁▇

skim_variable	n_missing	complete_rate	mean	sd	p0	p25	p50	p75	p100	hist
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	▃▇▇▅▂

The winpercent column is off scale compared to the other data.

> Q7. What do you think a zero and one represent for the candy$chocolate column?

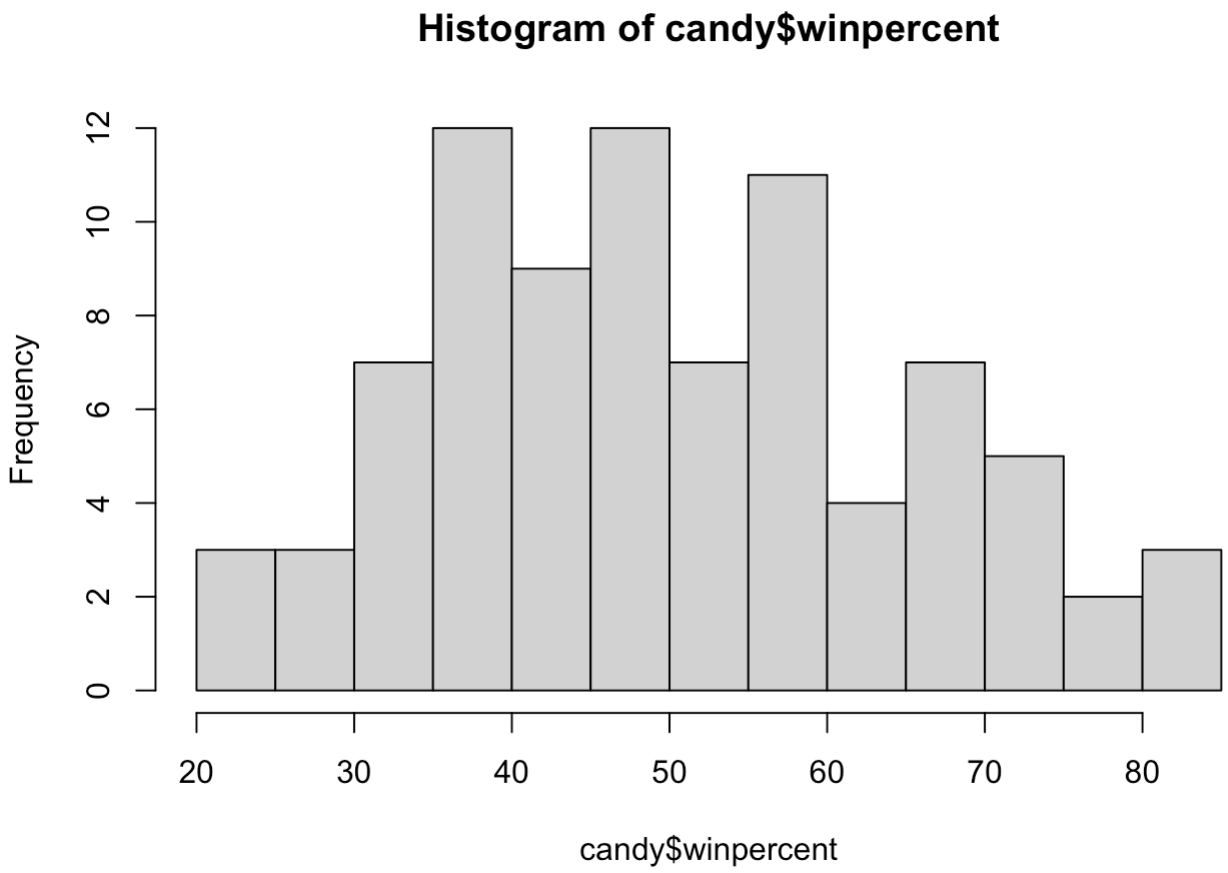
```
candy$chocolate
```

```
 [1] 1 1 0 0 0 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 0 1 1 0 0 0 1 1 0 1 1 1
[39] 1 1 1 0 1 1 0 0 0 1 0 0 0 1 1 1 1 0 1 0 0 1 0 0 1 0 1 1 0 0 0 0 0 0 0 0 1 1
[77] 1 1 0 1 0 0 0 0 1
```

The 0 and 1 are like a TRUE and FALSE, indicating whether the candy consists of chocolate or not.

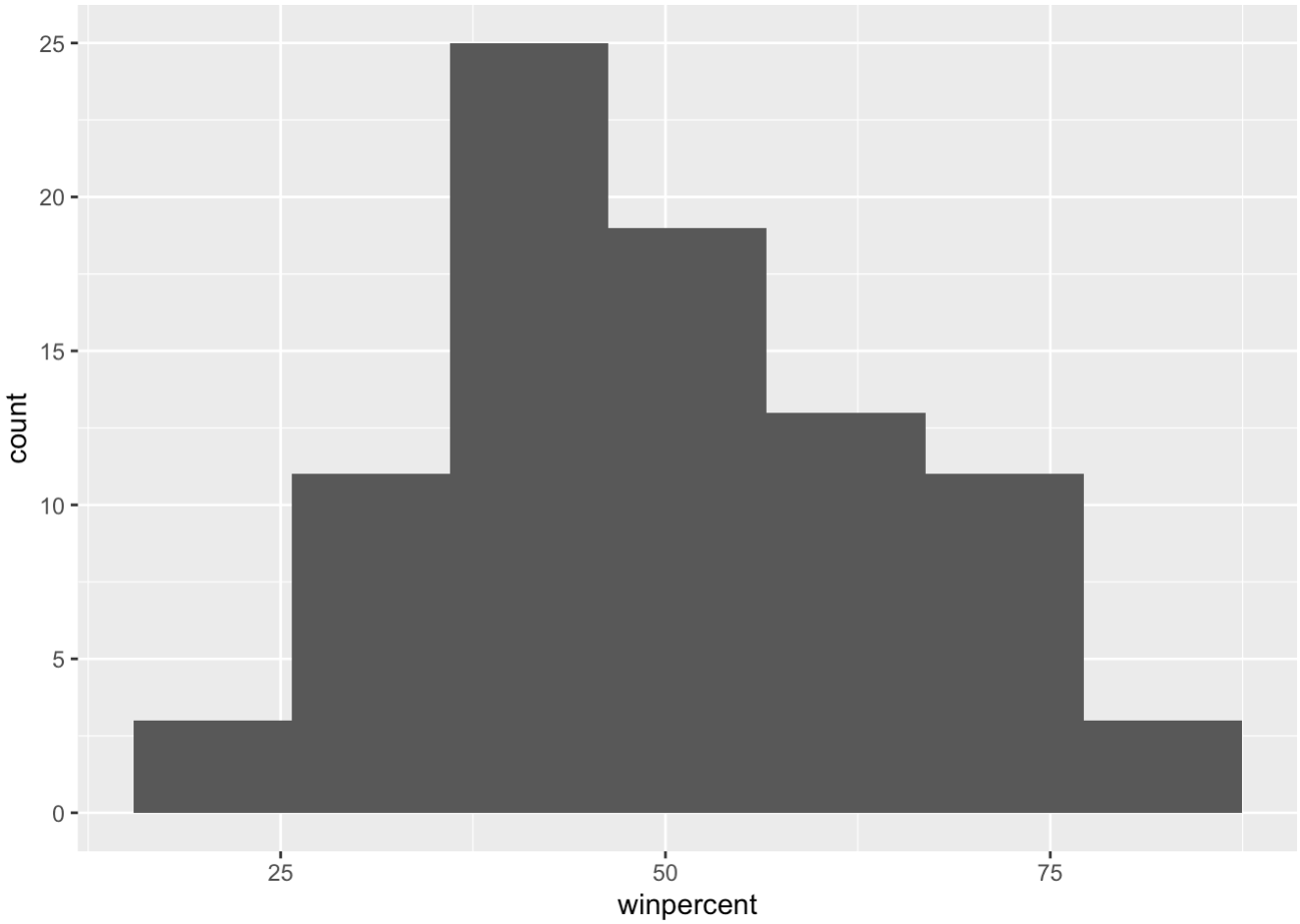
> Q8. Plot a histogram of winpercent values

```
hist(candy$winpercent, breaks=10)
```




```
library(ggplot2)
```

```
ggplot(candy) +
  aes(winpercent) +
  geom_histogram(bins=7)
```



> Q9. Is the distribution of winpercent values symmetrical?

No, there is a slight right-skew to the nature of the histogram.

> Q10. Is the center of the distribution above or below 50%?

```
mean(candy$winpercent)
```

```
[1] 50.31676
```

The center of distribution for winpercent is right above 50%, but visually, it appears as though it is below 50%.

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

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

```
[1] 60.92153
```

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

```
[1] 44.11974
```

> Q12. Is this difference statistically significant?

```
t.test(chocolate.win, fruity.win)
```

```

    Welch Two Sample t-test

data:  chocolate.win and fruity.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
```

```
my_cols=rep("darkgreen", nrow(candy))
my_cols[as.logical(candy$chocolate)] = "chocolate"
my_cols[as.logical(candy$bar)] = "brown"
my_cols[as.logical(candy$fruity)] = "pink"
my_cols
```

```
 [1] "brown"     "brown"     "darkgreen" "darkgreen" "pink"      "brown"
 [7] "brown"     "darkgreen" "darkgreen" "pink"      "brown"     "pink"
[13] "pink"      "pink"      "pink"      "pink"      "pink"      "pink"
[19] "pink"      "darkgreen" "pink"      "pink"      "chocolate" "brown"
[25] "brown"     "brown"     "pink"      "chocolate" "brown"     "pink"
[31] "pink"      "pink"      "chocolate" "chocolate" "pink"      "chocolate"
[37] "brown"     "brown"     "brown"     "brown"     "brown"     "pink"
[43] "brown"     "brown"     "pink"      "pink"      "brown"     "chocolate"
[49] "darkgreen" "pink"      "pink"      "chocolate" "chocolate" "chocolate"
[55] "chocolate" "pink"      "chocolate" "darkgreen" "pink"      "chocolate"
[61] "pink"      "pink"      "chocolate" "pink"      "brown"     "brown"
[67] "pink"      "pink"      "pink"      "pink"      "darkgreen" "darkgreen"
[73] "pink"      "pink"      "pink"      "chocolate" "chocolate" "brown"
[79] "pink"      "brown"     "pink"      "pink"      "pink"      "darkgreen"
[85] "chocolate"
```

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

```
inds <- order(candy$winpercent)
head(candy[inds,], 5)
```

```
                  chocolate fruity caramel peanutyalmondy nougat
Nik L Nip                 0      1       0              0      0
Boston Baked Beans        0      0       0              1      0
Chiclets                  0      1       0              0      0
Super Bubble              0      1       0              0      0
Jawbusters                0      1       0              0      0
                  crispedricewafer hard bar pluribus sugarpercent pricepercent
Nik L Nip                        0    0   0        1        0.197        0.976
Boston Baked Beans               0    0   0        1        0.313        0.511
Chiclets                         0    0   0        1        0.046        0.325
Super Bubble                     0    0   0        0        0.162        0.116
Jawbusters                       0    1   0        1        0.093        0.511
                  winpercent
Nik L Nip           22.44534
Boston Baked Beans  23.41782
Chiclets            24.52499
Super Bubble        27.30386
Jawbusters          28.12744
```

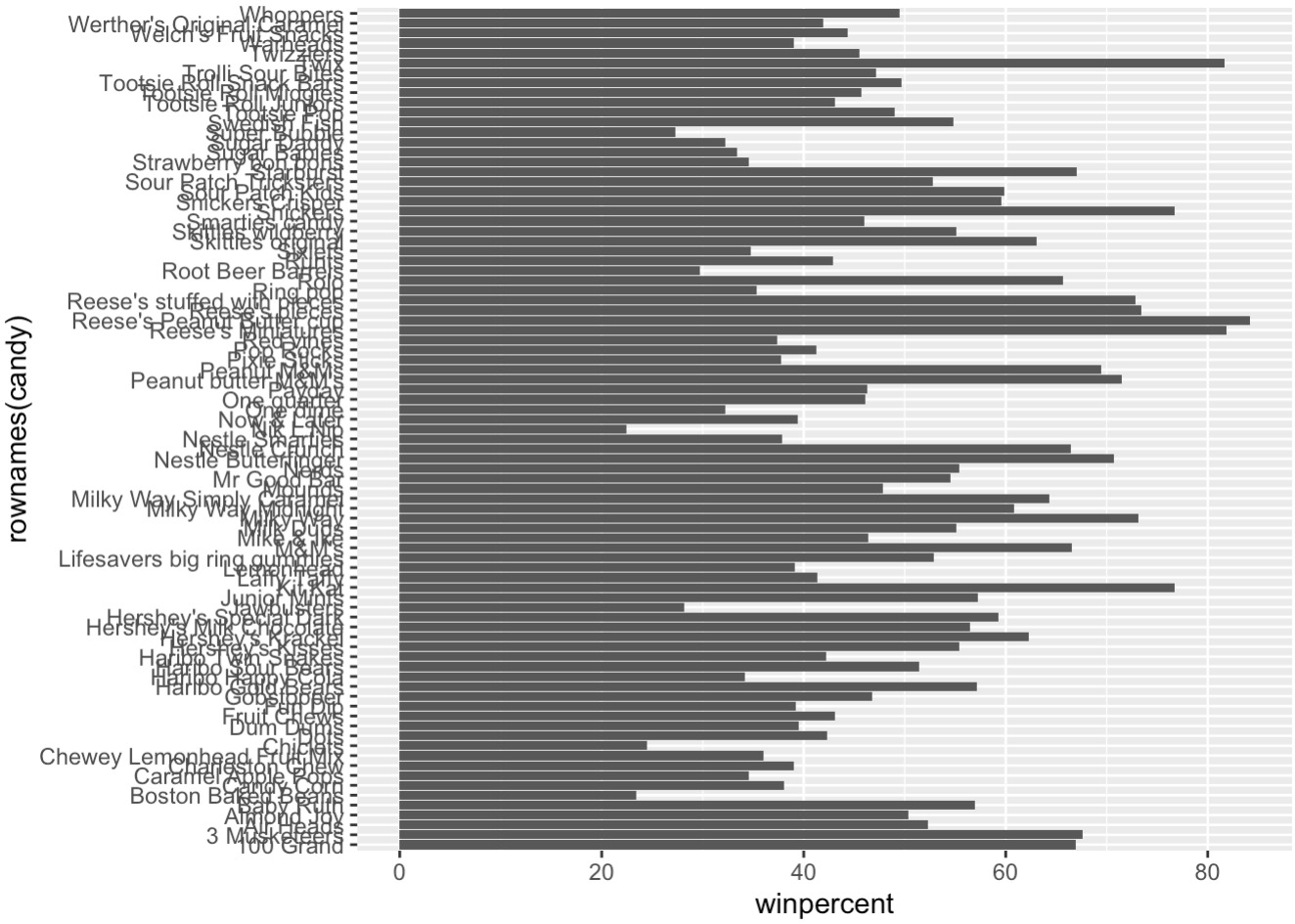
> Q14. What are the top 5 all time favorite candy types out of this set?

```
tail(candy[inds,], 5)
```

```
                        chocolate fruity caramel peanutyalmondy nougat
Snickers                        1      0       1              1      1
Kit Kat                         1      0       0              0      0
Twix                            1      0       1              0      0
Reese's Miniatures              1      0       0              1      0
Reese's Peanut Butter cup       1      0       0              1      0
                        crispedricewafer hard bar pluribus sugarpercent
Snickers                               0    0   1        0        0.546
Kit Kat                                1    0   1        0        0.313
Twix                                   1    0   1        0        0.546
Reese's Miniatures                     0    0   0        0        0.034
Reese's Peanut Butter cup              0    0   0        0        0.720
                        pricepercent winpercent
Snickers                       0.651   76.67378
Kit Kat                        0.511   76.76860
Twix                           0.906   81.64291
Reese's Miniatures             0.279   81.86626
Reese's Peanut Butter cup      0.651   84.18029
```

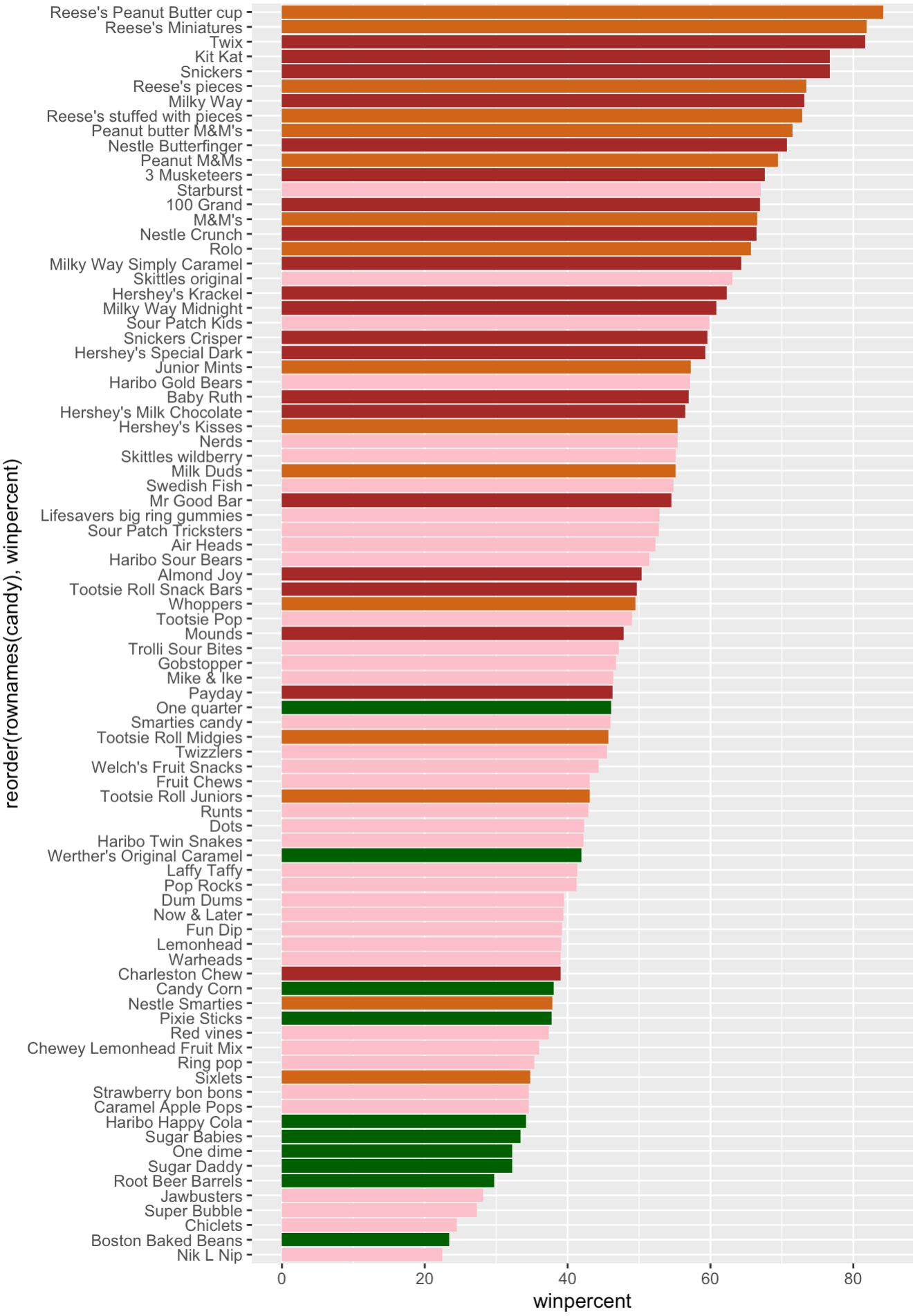
> Q15. Make a first barplot of candy ranking based on winpercent values.

```
ggplot(candy) +
  aes(winpercent, rownames(candy)) +
  geom_col()
```



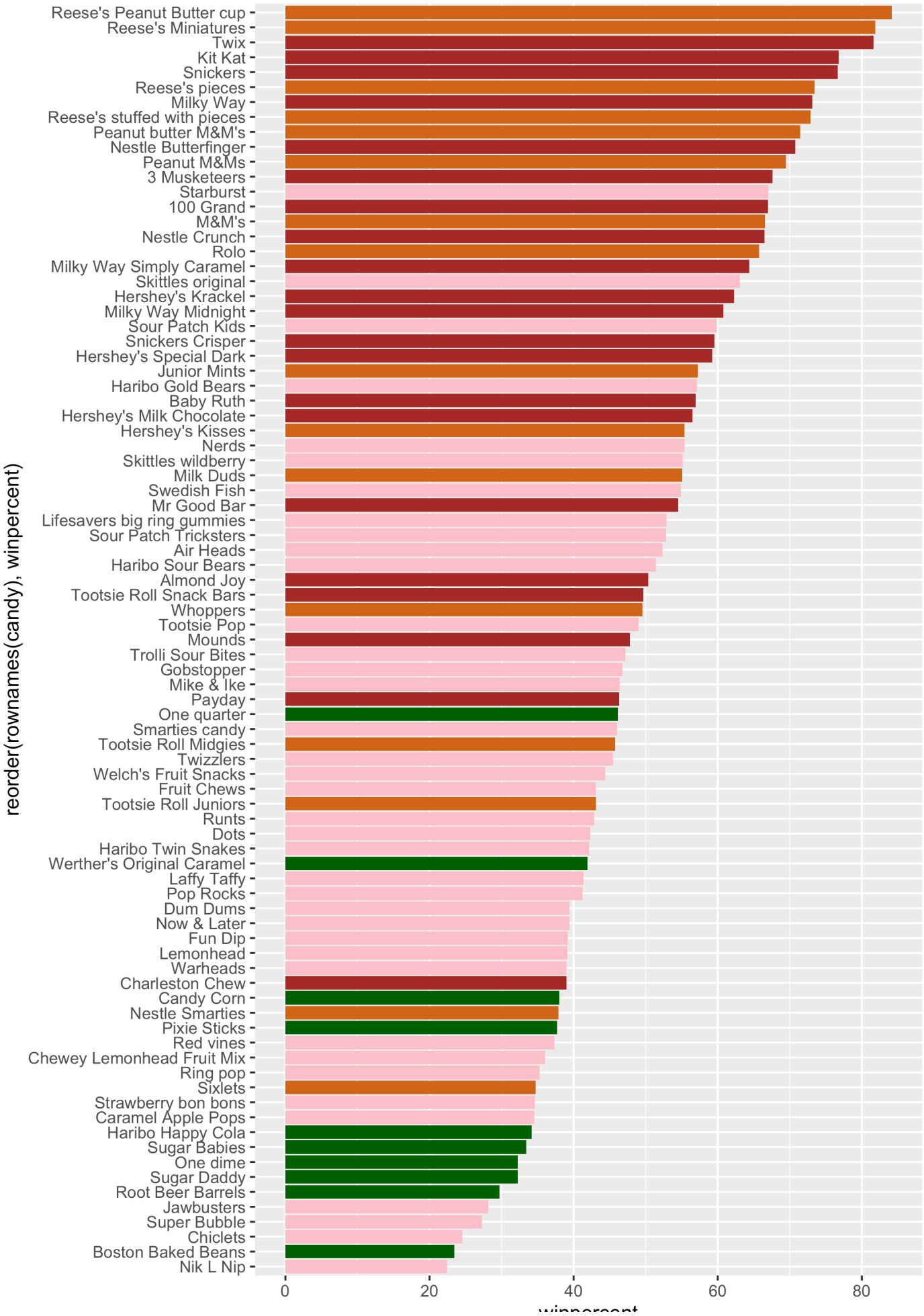
Q16. This is quite ugly, use the reorder() function to get the bars sorted by winpercent.

```
ggplot(candy) +
  aes(winpercent, reorder(rownames(candy), winpercent)) +
  geom_col(fill=my_cols)
```


Reese's Peanut Butter cup
Reese's Miniatures
Twix
Kit Kat
Snickers
Reese's pieces
Milky Way
Reese's stuffed with pieces
Peanut butter M&M's
Nestle Butterfinger
Peanut M&Ms
3 Musketeers
Starburst
100 Grand
M&M's
Nestle Crunch
Rolo
Milky Way Simply Caramel
Skittles original
Hershey's Krackel
Milky Way Midnight
Sour Patch Kids
Snickers Crisper
Hershey's Special Dark
Junior Mints
Haribo Gold Bears
Baby Ruth
Hershey's Milk Chocolate
Hershey's Kisses
Nerds
Skittles wildberry
Milk Duds
Swedish Fish
Mr Good Bar
Lifesavers big ring gummies
Sour Patch Tricksters
Air Heads
Haribo Sour Bears
Almond Joy
Tootsie Roll Snack Bars
Whoppers
Tootsie Pop
Mounds
Trolli Sour Bites
Gobstopper
Mike & Ike
Payday
One quarter
Smarties candy
Tootsie Roll Midgies
Twizzlers
Welch's Fruit Snacks
Fruit Chews
Tootsie Roll Juniors
Runts
Dots
Haribo Twin Snakes
Werther's Original Caramel
Laffy Taffy
Pop Rocks
Dum Dums
Now & Later
Fun Dip
Lemonhead
Warheads
Charleston Chew
Candy Corn
Nestle Smarties
Pixie Sticks
Red vines
Chewey Lemonhead Fruit Mix
Ring pop
Sixlets
Strawberry bon bons
Caramel Apple Pops
Haribo Happy Cola
Sugar Babies
One dime
Sugar Daddy
Root Beer Barrels
Jawbusters
Super Bubble
Chiclets
Boston Baked Beans
Nik L Nip
reorder(rownames(candy), winpercent)
0
20
40
60
80
winpercent

```
ggsave("mybarplot.png", height=10)
```

```
Saving 7 x 10 in image
```


reorder(rownames(candy), winpercent)
Reese's Peanut Butter cup
Reese's Miniatures
Twix
Kit Kat
Snickers
Reese's pieces
Milky Way
Reese's stuffed with pieces
Peanut butter M&M's
Nestle Butterfinger
Peanut M&Ms
3 Musketeers
Starburst
100 Grand
M&M's
Nestle Crunch
Rolo
Milky Way Simply Caramel
Skittles original
Hershey's Krackel
Milky Way Midnight
Sour Patch Kids
Snickers Crisper
Hershey's Special Dark
Junior Mints
Haribo Gold Bears
Baby Ruth
Hershey's Milk Chocolate
Hershey's Kisses
Nerds
Skittles wildberry
Milk Duds
Swedish Fish
Mr Good Bar
Lifesavers big ring gummies
Sour Patch Tricksters
Air Heads
Haribo Sour Bears
Almond Joy
Tootsie Roll Snack Bars
Whoppers
Tootsie Pop
Mounds
Trolli Sour Bites
Gobstopper
Mike & Ike
Payday
One quarter
Smarties candy
Tootsie Roll Midgies
Twizzlers
Welch's Fruit Snacks
Fruit Chews
Tootsie Roll Juniors
Runts
Dots
Haribo Twin Snakes
Werther's Original Caramel
Laffy Taffy
Pop Rocks
Dum Dums
Now & Later
Fun Dip
Lemonhead
Warheads
Charleston Chew
Candy Corn
Nestle Smarties
Pixie Sticks
Red vines
Chewey Lemonhead Fruit Mix
Ring pop
Sixlets
Strawberry bon bons
Caramel Apple Pops
Haribo Happy Cola
Sugar Babies
One dime
Sugar Daddy
Root Beer Barrels
Jawbusters
Super Bubble
Chiclets
Boston Baked Beans
Nik L Nip
0
20
40
60
80
winpercent

winpercent

Exported image that is a bit bigger so I can read it

```
my_cols=rep("darkgreen", nrow(candy))
my_cols[as.logical(candy$chocolate)] = "chocolate"
my_cols[as.logical(candy$bar)] = "brown"
my_cols[as.logical(candy$fruity)] = "pink"
my_cols
```

```
 [1] "brown"     "brown"     "darkgreen" "darkgreen" "pink"      "brown"
 [7] "brown"     "darkgreen" "darkgreen" "pink"      "brown"     "pink"
[13] "pink"      "pink"      "pink"      "pink"      "pink"      "pink"
[19] "pink"      "darkgreen" "pink"      "pink"      "chocolate" "brown"
[25] "brown"     "brown"     "pink"      "chocolate" "brown"     "pink"
[31] "pink"      "pink"      "chocolate" "chocolate" "pink"      "chocolate"
[37] "brown"     "brown"     "brown"     "brown"     "brown"     "pink"
[43] "brown"     "brown"     "pink"      "pink"      "brown"     "chocolate"
[49] "darkgreen" "pink"      "pink"      "chocolate" "chocolate" "chocolate"
[55] "chocolate" "pink"      "chocolate" "darkgreen" "pink"      "chocolate"
[61] "pink"      "pink"      "chocolate" "pink"      "brown"     "brown"
[67] "pink"      "pink"      "pink"      "pink"      "darkgreen" "darkgreen"
[73] "pink"      "pink"      "pink"      "chocolate" "chocolate" "brown"
[79] "pink"      "brown"     "pink"      "pink"      "pink"      "darkgreen"
[85] "chocolate"
```

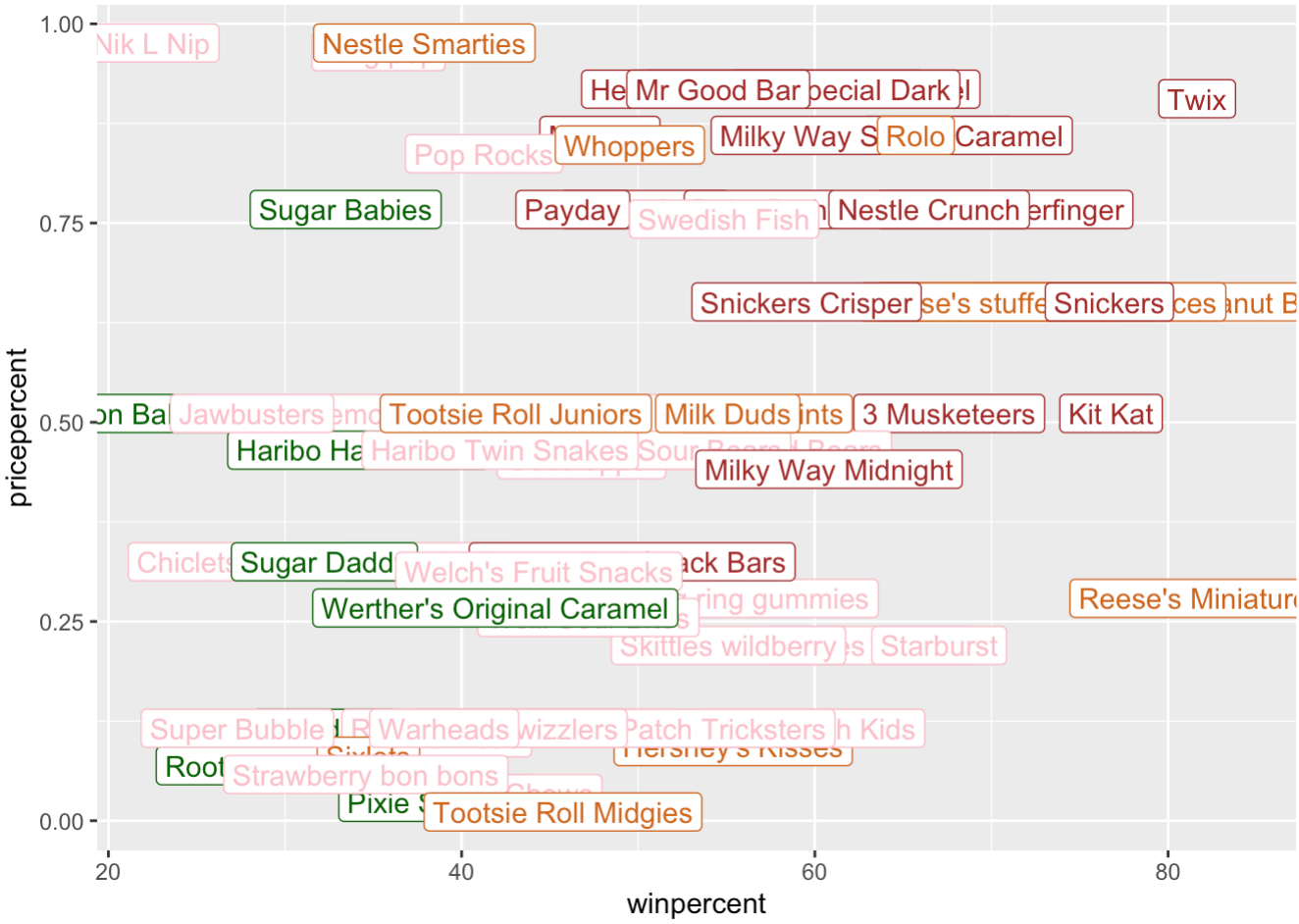
> Q17. What is the worst ranked chocolate candy?

Nik L Nip

> Q18. What is the best ranked fruity candy?

Starburst

```
ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols) +
  geom_label(col=my_cols)
```




```
library(ggrepel)

ggplot(candy) +
  aes(winpercent, pricepercent, label=rownames(candy)) +
  geom_point(col=my_cols) +
  geom_text(col=my_cols, max.overlaps = 5, size = 3.3)
```

```
Warning in geom_text(col = my_cols, max.overlaps = 5, size = 3.3): Ignoring
unknown parameters: `max.overlaps`
```

> 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?

Reese's miniature is one option.

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

Nik L Nip, Ring Pop, Nestle's Smarties, Pop Rocks, Mounds. Nik L Nip is the least popular.

Exploring the Correlation Structure

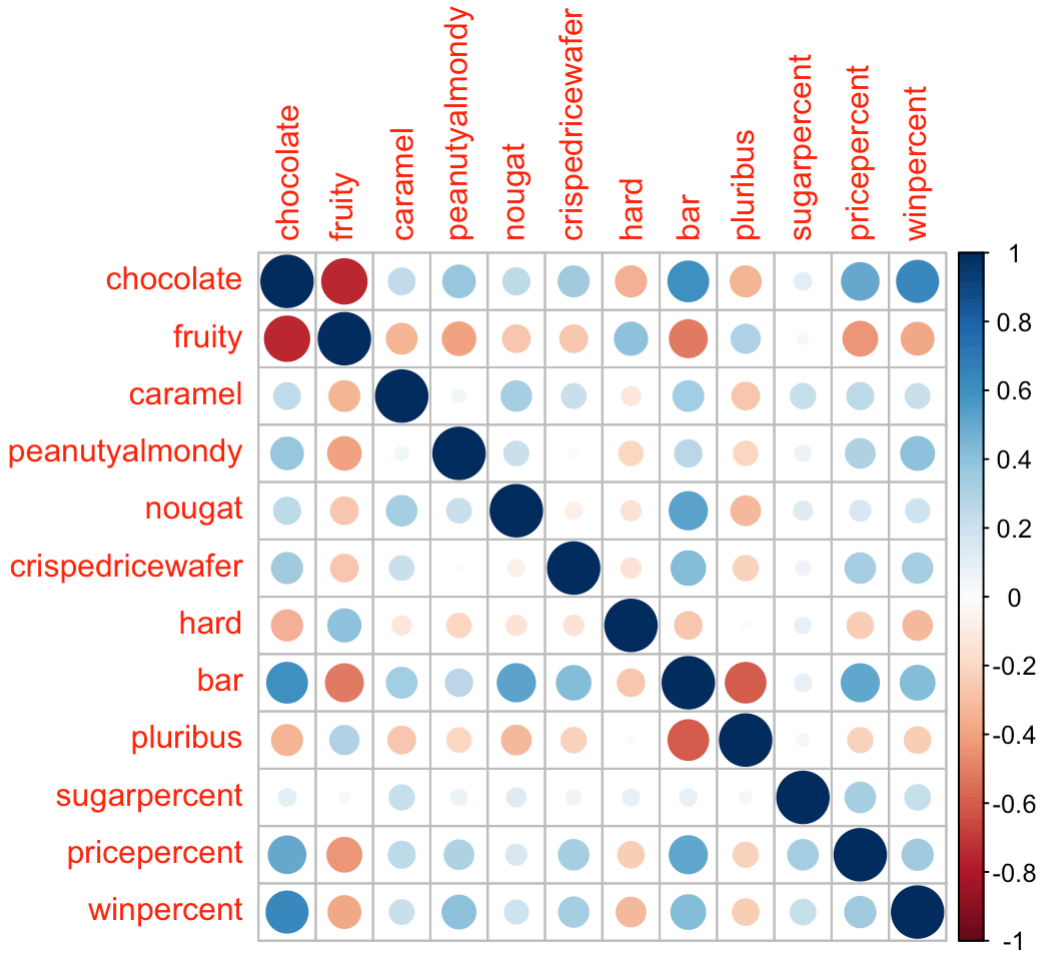
```
library(corrplot)
```

```
corrplot 0.92 loaded
```

```
cij <- cor(candy)
cij
```

```
                  chocolate      fruity     caramel peanutyalmondy      nougat
chocolate         1.0000000 -0.74172106  0.24987535     0.37782357  0.25489183
fruity           -0.7417211  1.00000000 -0.33548538    -0.39928014 -0.26936712
caramel           0.2498753 -0.33548538  1.00000000     0.05935614  0.32849280
peanutyalmondy    0.3778236 -0.39928014  0.05935614     1.00000000  0.21311310
nougat            0.2548918 -0.26936712  0.32849280     0.21311310  1.00000000
crispedricewafer  0.3412098 -0.26936712  0.21311310    -0.01764631 -0.08974359
hard             -0.3441769  0.39067750 -0.12235513    -0.20555661 -0.13867505
bar               0.5974211 -0.51506558  0.33396002     0.26041960  0.52297636
pluribus         -0.3396752  0.29972522 -0.26958501    -0.20610932 -0.31033884
sugarpercent      0.1041691 -0.03439296  0.22193335     0.08788927  0.12308135
pricepercent      0.5046754 -0.43096853  0.25432709     0.30915323  0.15319643
winpercent        0.6365167 -0.38093814  0.21341630     0.40619220  0.19937530
                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
                sugarpercent pricepercent winpercent
chocolate         0.10416906    0.5046754  0.6365167
fruity           -0.03439296   -0.4309685 -0.3809381
caramel           0.22193335    0.2543271  0.2134163
peanutyalmondy    0.08788927    0.3091532  0.4061922
nougat            0.12308135    0.1531964  0.1993753
crispedricewafer  0.06994969    0.3282654  0.3246797
hard              0.09180975   -0.2443653 -0.3103816
bar               0.09998516    0.5184065  0.4299293
pluribus          0.04552282   -0.2207936 -0.2474479
sugarpercent      1.00000000    0.3297064  0.2291507
pricepercent      0.32970639    1.0000000  0.3453254
winpercent        0.22915066    0.3453254  1.0000000
```

```
corrplot(cij)
```



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

Fruity and chocolate have a very strong anti-correlation

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

Chocolate and winpercent are most positively correlated.

6. PCA

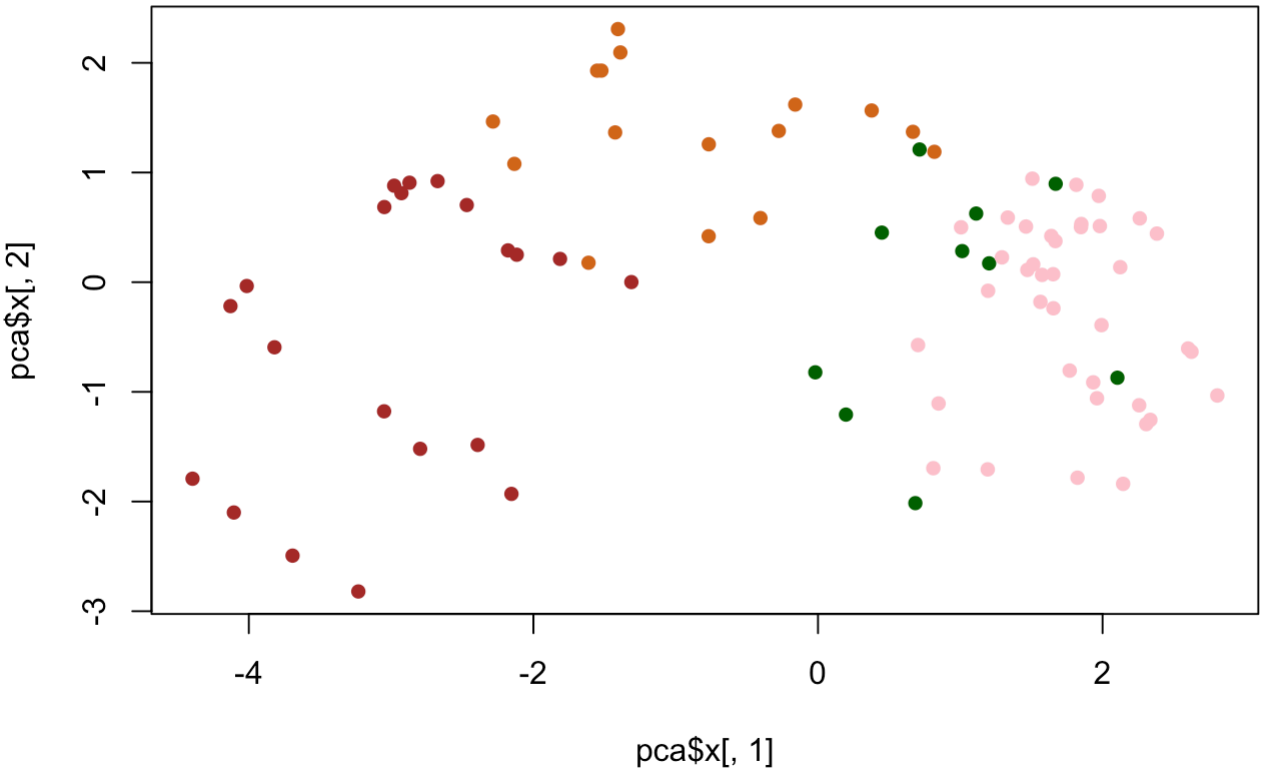
We will perform PCA of the candy. Do we need to scale the data before PCA?

```
pca <- prcomp(candy, scale=TRUE)
summary(pca)
```

```
Importance of components:
                          PC1    PC2    PC3     PC4    PC5     PC6     PC7
Standard deviation     2.0788 1.1378 1.1092 1.07533 0.9518 0.81923 0.81530
Proportion of Variance 0.3601 0.1079 0.1025 0.09636 0.0755 0.05593 0.05539
Cumulative Proportion  0.3601 0.4680 0.5705 0.66688 0.7424 0.79830 0.85369
                          PC8     PC9    PC10    PC11    PC12
```

```
Standard deviation     0.74530 0.67824 0.62349 0.43974 0.39760
Proportion of Variance 0.04629 0.03833 0.03239 0.01611 0.01317
Cumulative Proportion  0.89998 0.93832 0.97071 0.98683 1.00000
```

```
plot(pca$x[,1], pca$x[,2], col=my_cols, pch=16)
```



ggplot version:

```
# Make a new data-frame with our PCA results and candy data
my_data <- cbind(candy, pca$x[,1:3])
my_data
```

```
                           chocolate fruity caramel peanutyalmondy nougat
100 Grand                          1      0       1              0      0
3 Musketeers                       1      0       0              0      1
One dime                           0      0       0              0      0
One quarter                        0      0       0              0      0
Air Heads                          0      1       0              0      0
Almond Joy                         1      0       0              1      0
Baby Ruth                          1      0       1              1      1
Boston Baked Beans                 0      0       0              1      0
Candy Corn                         0      0       0              0      0
Caramel Apple Pops                 0      1       1              0      0
Charleston Chew                    1      0       0              0      1
```

Chewey Lemonhead Fruit Mix	0	1	0	0	0
Chiclets	0	1	0	0	0
Dots	0	1	0	0	0
Dum Dums	0	1	0	0	0
Fruit Chews	0	1	0	0	0
Fun Dip	0	1	0	0	0
Gobstopper	0	1	0	0	0
Haribo Gold Bears	0	1	0	0	0
Haribo Happy Cola	0	0	0	0	0
Haribo Sour Bears	0	1	0	0	0
Haribo Twin Snakes	0	1	0	0	0
Hershey's Kisses	1	0	0	0	0
Hershey's Krackel	1	0	0	0	0
Hershey's Milk Chocolate	1	0	0	0	0
Hershey's Special Dark	1	0	0	0	0
Jawbusters	0	1	0	0	0
Junior Mints	1	0	0	0	0
Kit Kat	1	0	0	0	0
Laffy Taffy	0	1	0	0	0
Lemonhead	0	1	0	0	0
Lifesavers big ring gummies	0	1	0	0	0
Peanut butter M&M's	1	0	0	1	0
M&M's	1	0	0	0	0
Mike & Ike	0	1	0	0	0
Milk Duds	1	0	1	0	0
Milky Way	1	0	1	0	1
Milky Way Midnight	1	0	1	0	1
Milky Way Simply Caramel	1	0	1	0	0
Mounds	1	0	0	0	0
Mr Good Bar	1	0	0	1	0
Nerds	0	1	0	0	0
Nestle Butterfinger	1	0	0	1	0
Nestle Crunch	1	0	0	0	0
Nik L Nip	0	1	0	0	0
Now & Later	0	1	0	0	0
Payday	0	0	0	1	1
Peanut M&Ms	1	0	0	1	0
Pixie Sticks	0	0	0	0	0
Pop Rocks	0	1	0	0	0
Red vines	0	1	0	0	0
Reese's Miniatures	1	0	0	1	0
Reese's Peanut Butter cup	1	0	0	1	0
Reese's pieces	1	0	0	1	0
Reese's stuffed with pieces	1	0	0	1	0
Ring pop	0	1	0	0	0
Rolo	1	0	1	0	0
Root Beer Barrels	0	0	0	0	0
Runts	0	1	0	0	0
Sixlets	1	0	0	0	0
Skittles original	0	1	0	0	0
Skittles wildberry	0	1	0	0	0

Nestle Smarties	1	0	0	0	0
Smarties candy	0	1	0	0	0
Snickers	1	0	1	1	1
Snickers Crisper	1	0	1	1	0
Sour Patch Kids	0	1	0	0	0
Sour Patch Tricksters	0	1	0	0	0
Starburst	0	1	0	0	0
Strawberry bon bons	0	1	0	0	0
Sugar Babies	0	0	1	0	0
Sugar Daddy	0	0	1	0	0
Super Bubble	0	1	0	0	0
Swedish Fish	0	1	0	0	0
Tootsie Pop	1	1	0	0	0
Tootsie Roll Juniors	1	0	0	0	0
Tootsie Roll Midgies	1	0	0	0	0
Tootsie Roll Snack Bars	1	0	0	0	0
Trolli Sour Bites	0	1	0	0	0
Twix	1	0	1	0	0
Twizzlers	0	1	0	0	0
Warheads	0	1	0	0	0
Welch's Fruit Snacks	0	1	0	0	0
Werther's Original Caramel	0	0	1	0	0
Whoppers	1	0	0	0	0

	crispedricewafer	hard	bar	pluribus	sugarpercent
100 Grand	1	0	1	0	0.732
3 Musketeers	0	0	1	0	0.604
One dime	0	0	0	0	0.011
One quarter	0	0	0	0	0.011
Air Heads	0	0	0	0	0.906
Almond Joy	0	0	1	0	0.465
Baby Ruth	0	0	1	0	0.604
Boston Baked Beans	0	0	0	1	0.313
Candy Corn	0	0	0	1	0.906
Caramel Apple Pops	0	0	0	0	0.604
Charleston Chew	0	0	1	0	0.604
Chewey Lemonhead Fruit Mix	0	0	0	1	0.732
Chiclets	0	0	0	1	0.046
Dots	0	0	0	1	0.732
Dum Dums	0	1	0	0	0.732
Fruit Chews	0	0	0	1	0.127
Fun Dip	0	1	0	0	0.732
Gobstopper	0	1	0	1	0.906
Haribo Gold Bears	0	0	0	1	0.465
Haribo Happy Cola	0	0	0	1	0.465
Haribo Sour Bears	0	0	0	1	0.465
Haribo Twin Snakes	0	0	0	1	0.465
Hershey's Kisses	0	0	0	1	0.127
Hershey's Krackel	1	0	1	0	0.430
Hershey's Milk Chocolate	0	0	1	0	0.430
Hershey's Special Dark	0	0	1	0	0.430
Jawbusters	0	1	0	1	0.093

Junior Mints	0	0	0	1	0.197
Kit Kat	1	0	1	0	0.313
Laffy Taffy	0	0	0	0	0.220
Lemonhead	0	1	0	0	0.046
Lifesavers big ring gummies	0	0	0	0	0.267
Peanut butter M&M's	0	0	0	1	0.825
M&M's	0	0	0	1	0.825
Mike & Ike	0	0	0	1	0.872
Milk Duds	0	0	0	1	0.302
Milky Way	0	0	1	0	0.604
Milky Way Midnight	0	0	1	0	0.732
Milky Way Simply Caramel	0	0	1	0	0.965
Mounds	0	0	1	0	0.313
Mr Good Bar	0	0	1	0	0.313
Nerds	0	1	0	1	0.848
Nestle Butterfinger	0	0	1	0	0.604
Nestle Crunch	1	0	1	0	0.313
Nik L Nip	0	0	0	1	0.197
Now & Later	0	0	0	1	0.220
Payday	0	0	1	0	0.465
Peanut M&Ms	0	0	0	1	0.593
Pixie Sticks	0	0	0	1	0.093
Pop Rocks	0	1	0	1	0.604
Red vines	0	0	0	1	0.581
Reese's Miniatures	0	0	0	0	0.034
Reese's Peanut Butter cup	0	0	0	0	0.720
Reese's pieces	0	0	0	1	0.406
Reese's stuffed with pieces	0	0	0	0	0.988
Ring pop	0	1	0	0	0.732
Rolo	0	0	0	1	0.860
Root Beer Barrels	0	1	0	1	0.732
Runts	0	1	0	1	0.872
Sixlets	0	0	0	1	0.220
Skittles original	0	0	0	1	0.941
Skittles wildberry	0	0	0	1	0.941
Nestle Smarties	0	0	0	1	0.267
Smarties candy	0	1	0	1	0.267
Snickers	0	0	1	0	0.546
Snickers Crisper	1	0	1	0	0.604
Sour Patch Kids	0	0	0	1	0.069
Sour Patch Tricksters	0	0	0	1	0.069
Starburst	0	0	0	1	0.151
Strawberry bon bons	0	1	0	1	0.569
Sugar Babies	0	0	0	1	0.965
Sugar Daddy	0	0	0	0	0.418
Super Bubble	0	0	0	0	0.162
Swedish Fish	0	0	0	1	0.604
Tootsie Pop	0	1	0	0	0.604
Tootsie Roll Juniors	0	0	0	0	0.313
Tootsie Roll Midgies	0	0	0	1	0.174
Tootsie Roll Snack Bars	0	0	1	0	0.465

Trolli Sour Bites	0	0	0	1	0.313	
Twix	1	0	1	0	0.546	
Twizzlers	0	0	0	0	0.220	
Warheads	0	1	0	0	0.093	
Welch's Fruit Snacks	0	0	0	1	0.313	
Werther's Original Caramel	0	1	0	0	0.186	
Whoppers	1	0	0	1	0.872	

	pricepercent	winpercent	PC1	PC2
100 Grand	0.860	66.97173	-3.81986175	-0.5935787670
3 Musketeers	0.511	67.60294	-2.79602364	-1.5196062111
One dime	0.116	32.26109	1.20258363	0.1718120657
One quarter	0.511	46.11650	0.44865378	0.4519735621
Air Heads	0.511	52.34146	0.70289922	-0.5731343263
Almond Joy	0.767	50.34755	-2.46833834	0.7035501120
Baby Ruth	0.767	56.91455	-4.10531223	-2.1000967736
Boston Baked Beans	0.511	23.41782	0.71385813	1.2098216537
Candy Corn	0.325	38.01096	1.01357204	0.2834319621
Caramel Apple Pops	0.325	34.51768	0.81049645	-1.6960889498
Charleston Chew	0.511	38.97504	-2.15436587	-1.9304213037
Chewey Lemonhead Fruit Mix	0.511	36.01763	1.65268482	0.0726434944
Chiclets	0.325	24.52499	2.38180817	0.4430926071
Dots	0.511	42.27208	1.51249936	0.1623958592
Dum Dums	0.034	39.46056	2.14430933	-1.8388386160
Fruit Chews	0.034	43.08892	2.26133763	0.5818322520
Fun Dip	0.325	39.18550	1.82383348	-1.7828662094
Gobstopper	0.453	46.78335	1.96047812	-1.0584680267
Haribo Gold Bears	0.465	57.11974	1.33360746	0.5892699921
Haribo Happy Cola	0.465	34.15896	1.11167365	0.6257697808
Haribo Sour Bears	0.465	51.41243	1.46152952	0.5073691482
Haribo Twin Snakes	0.465	42.17877	1.66849016	0.3748646265
Hershey's Kisses	0.093	55.37545	0.37722675	1.5654519145
Hershey's Krackel	0.918	62.28448	-3.04788356	0.6850792787
Hershey's Milk Chocolate	0.918	56.49050	-2.11696417	0.2504568891
Hershey's Special Dark	0.918	59.23612	-2.17850376	0.2898570052
Jawbusters	0.511	28.12744	2.62491587	-0.6343671618
Junior Mints	0.511	57.21925	-0.16010610	1.6194428347
Kit Kat	0.511	76.76860	-2.87086546	0.9069655335
Laffy Taffy	0.116	41.38956	1.65450042	-0.2379605144
Lemonhead	0.104	39.14106	2.33564695	-1.2553404646
Lifesavers big ring gummies	0.279	52.91139	1.19528766	-0.0783610246
Peanut butter M&M's	0.651	71.46505	-1.52223814	1.9291395890
M&M's	0.651	66.57458	-0.76747561	1.2573539136
Mike & Ike	0.325	46.41172	1.57487290	0.0664259746
Milk Duds	0.511	55.06407	-0.76836937	0.4192793946
Milky Way	0.651	73.09956	-3.69272218	-2.4933313173
Milky Way Midnight	0.441	60.80070	-3.23036513	-2.8201031327
Milky Way Simply Caramel	0.860	64.35334	-3.04936226	-1.1774777304
Mounds	0.860	47.82975	-1.81292795	0.2120726312
Mr Good Bar	0.918	54.52645	-2.67327849	0.9217207344
Nerds	0.325	55.35405	1.93426895	-0.9133307225
Nestle Butterfinger	0.767	70.73564	-2.97855081	0.8798835368

Nestle Crunch	0.767	66.47068	-2.92740488	0.8119013154
Nik L Nip	0.976	22.44534	1.63985272	0.4210217322
Now & Later	0.325	39.44680	1.98070982	0.5117150919
Payday	0.767	46.29660	-2.39180556	-1.4839637512
Peanut M&Ms	0.651	69.48379	-1.38897069	2.0947188031
Pixie Sticks	0.023	37.72234	1.67042227	0.8969792365
Pop Rocks	0.837	41.26551	1.76879348	-0.8060325640
Red vines	0.116	37.34852	2.12406849	0.1366822960
Reese's Miniatures	0.279	81.86626	-1.55210251	1.9287569793
Reese's Peanut Butter cup	0.651	84.18029	-2.28427985	1.4648923293
Reese's pieces	0.651	73.43499	-1.40590761	2.3077984818
Reese's stuffed with pieces	0.651	72.88790	-2.13382398	1.0787289654
Ring pop	0.965	35.29076	1.19274412	-1.7069749284
Rolo	0.860	65.71629	-1.61259322	0.1773734932
Root Beer Barrels	0.069	29.70369	2.10440254	-0.8711340556
Runts	0.279	42.84914	2.25699185	-1.1223199934
Sixlets	0.081	34.72200	0.81799664	1.1888290122
Skittles original	0.220	63.08514	1.29259129	0.2263705137
Skittles wildberry	0.220	55.10370	1.47148517	0.1118354559
Nestle Smarties	0.976	37.88719	-0.27556563	1.3792344137
Smarties candy	0.116	45.99583	2.60115214	-0.6047947520
Snickers	0.651	76.67378	-4.39576792	-1.7919312516
Snickers Crisper	0.651	59.52925	-4.01457335	-0.0347673522
Sour Patch Kids	0.116	59.86400	1.81551769	0.8879445215
Sour Patch Tricksters	0.116	52.82595	1.97326660	0.7869473239
Starburst	0.220	67.03763	1.50658493	0.9437290830
Strawberry bon bons	0.058	34.57899	2.80647837	-1.0331193111
Sugar Babies	0.767	33.43755	-0.01900559	-0.8219542293
Sugar Daddy	0.325	32.23100	0.19642038	-1.2073694698
Super Bubble	0.116	27.30386	1.99242820	-0.3915898648
Swedish Fish	0.755	54.86111	1.00547407	0.5003327040
Tootsie Pop	0.325	48.98265	0.84734171	-1.1060686710
Tootsie Roll Juniors	0.511	43.06890	-0.40463667	0.5848580362
Tootsie Roll Midgies	0.011	45.73675	0.66730732	1.3709464980
Tootsie Roll Snack Bars	0.325	49.65350	-1.31149842	0.0009721286
Trolli Sour Bites	0.255	47.17323	1.85048456	0.5304055168
Twix	0.906	81.64291	-4.12909044	-0.2180299573
Twizzlers	0.116	45.46628	1.56312584	-0.1794588354
Warheads	0.116	39.01190	2.30707033	-1.2940268825
Welch's Fruit Snacks	0.313	44.37552	1.84808801	0.5022006184
Werther's Original Caramel	0.267	41.90431	0.68420363	-2.0146385440
Whoppers	0.848	49.52411	-1.42549552	1.3654147702

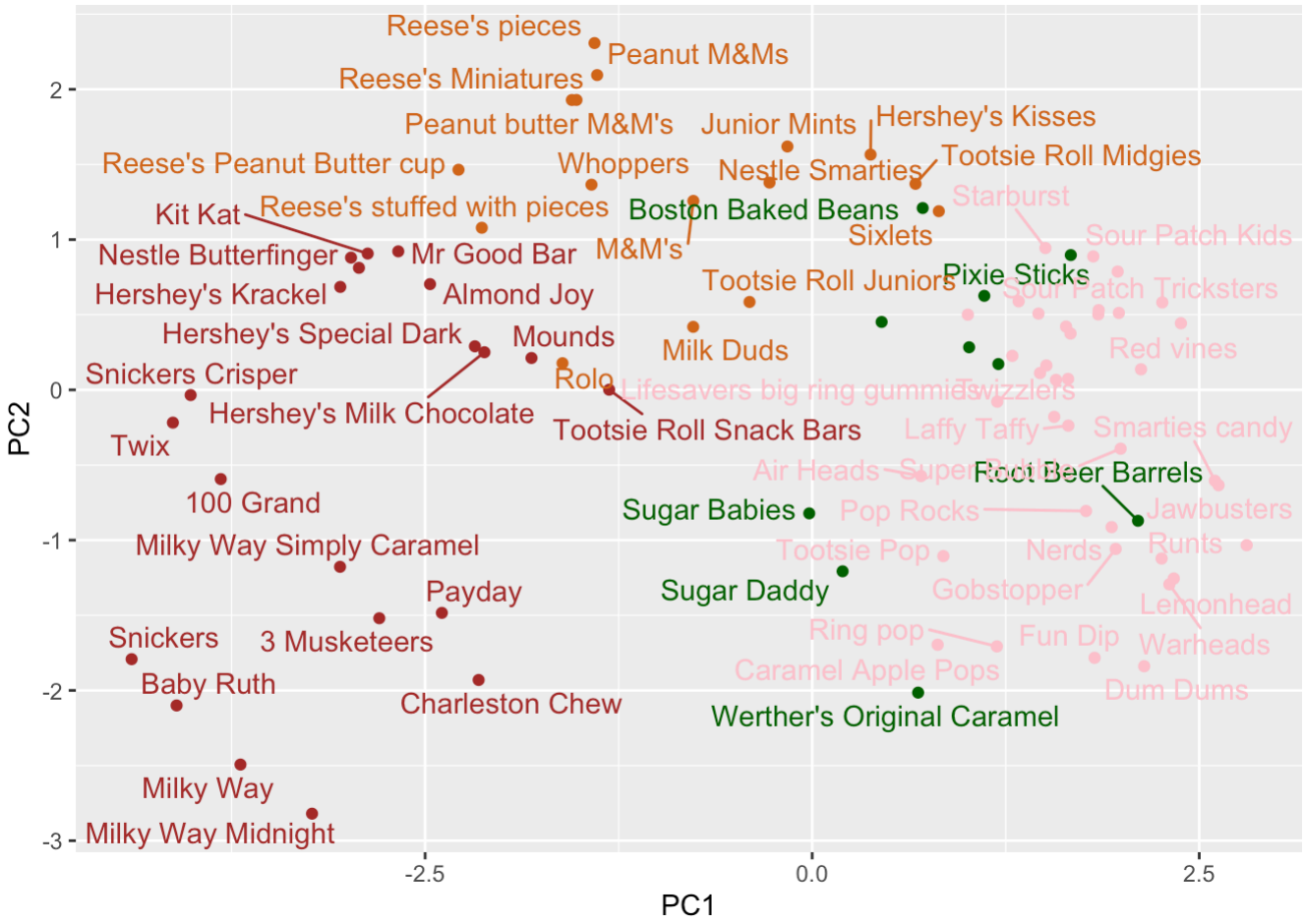
	PC3
100 Grand	-2.186308676
3 Musketeers	1.412198551
One dime	2.060771178
One quarter	1.476492844
Air Heads	-0.929389343
Almond Joy	0.858108916
Baby Ruth	1.347834706
Boston Baked Beans	0.941899950

Candy Corn	-0.840681586
Caramel Apple Pops	-0.207020586
Charleston Chew	1.675469334
Chewey Lemonhead Fruit Mix	-0.909617411
Chiclets	1.000422079
Dots	-0.967135199
Dum Dums	-0.385372660
Fruit Chews	0.978626618
Fun Dip	-0.719415821
Gobstopper	-1.873874385
Haribo Gold Bears	-0.431929774
Haribo Happy Cola	0.054459647
Haribo Sour Bears	-0.379443632
Haribo Twin Snakes	-0.294528131
Hershey's Kisses	1.104739528
Hershey's Krackel	-1.154357778
Hershey's Milk Chocolate	0.218316614
Hershey's Special Dark	0.193067056
Jawbusters	0.114043053
Junior Mints	0.442156347
Kit Kat	-0.545771148
Laffy Taffy	1.217408326
Lemonhead	1.125823900
Lifesavers big ring gummies	0.814040659
Peanut butter M&M's	-0.815897653
M&M's	-1.260658369
Mike & Ike	-1.114406454
Milk Duds	-0.137573021
Milky Way	0.843423990
Milky Way Midnight	0.902884388
Milky Way Simply Caramel	-1.382617058
Mounds	0.636094539
Mr Good Bar	0.997161433
Nerds	-1.670281710
Nestle Butterfinger	0.348599786
Nestle Crunch	-0.747159803
Nik L Nip	-0.083217936
Now & Later	0.460099768
Payday	2.091687409
Peanut M&Ms	-0.260214925
Pixie Sticks	1.394703254
Pop Rocks	-1.567639814
Red vines	-0.115183020
Reese's Miniatures	1.884620322
Reese's Peanut Butter cup	-0.156138940
Reese's pieces	0.136661895
Reese's stuffed with pieces	-0.673152403
Ring pop	-1.423826969
Rolo	-1.931879747
Root Beer Barrels	-0.594335570
Runts	-1.557678507

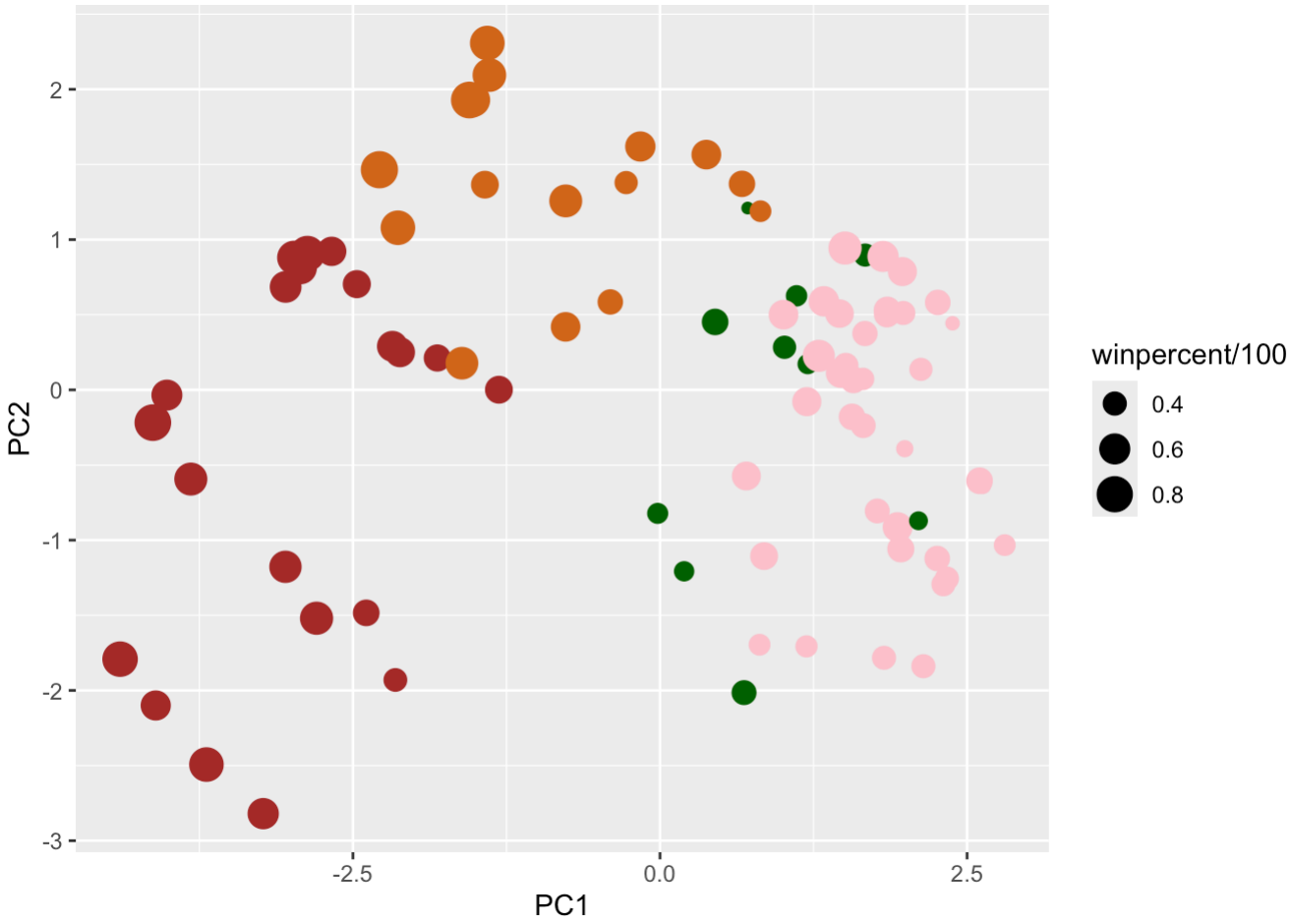
```
Sixlets                      1.093105891
Skittles original           -1.306145308
Skittles wildberry          -1.232745536
Nestle Smarties             -0.080047831
Smarties candy               0.003482896
Snickers                     1.434654778
Snickers Crisper            -1.089868643
Sour Patch Kids              0.863881832
Sour Patch Tricksters        0.928605869
Starburst                    0.487658690
Strawberry bon bons         -0.524069119
Sugar Babies                -1.802826526
Sugar Daddy                  0.520140143
Super Bubble                 1.481310204
Swedish Fish                -1.068588828
Tootsie Pop                 -0.480874078
Tootsie Roll Juniors         0.836999949
Tootsie Roll Midgies         1.179339290
Tootsie Roll Snack Bars      0.885976952
Trolli Sour Bites            0.254559391
Twix                        -1.943536689
Twizzlers                    1.179917535
Warheads                     1.004249910
Welch's Fruit Snacks         0.213204782
Werther's Original Caramel   0.506488679
Whoppers                    -2.759982292
```

```
ggplot(my_data) +
  aes(PC1, PC2, label=rownames(my_data)) +
  geom_point(col=my_cols) +
  geom_text_repel(col=my_cols)
```

```
Warning: ggrepel: 21 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```

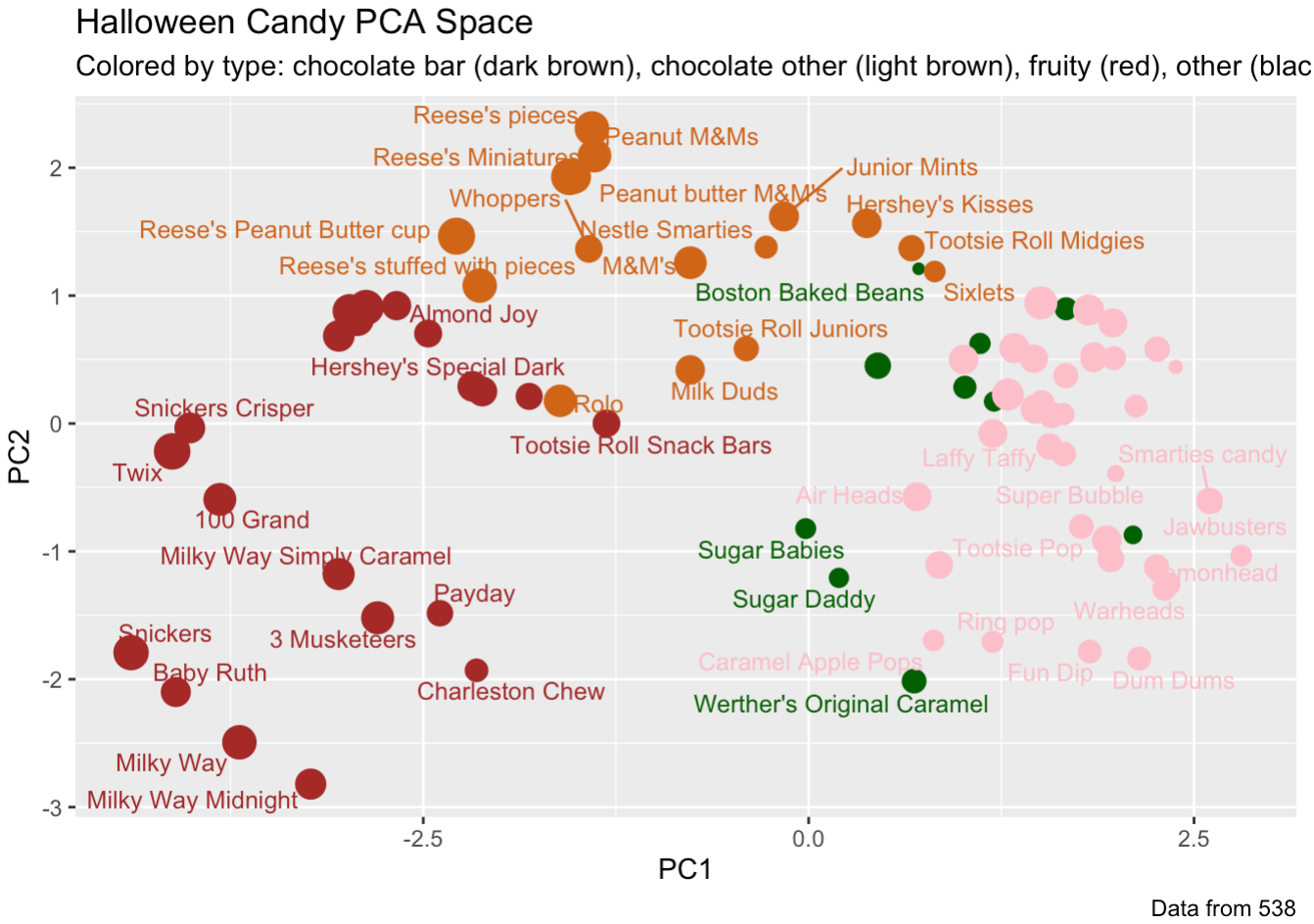



```
p <- ggplot(my_data) +
        aes(x=PC1, y=PC2,
            size=winpercent/100,
            text=rownames(my_data),
            label=rownames(my_data)) +
        geom_point(col=my_cols)

p
```




```
p + geom_text_repel(size=3.3, col=my_cols, max.overlaps = 7)  +
  theme(legend.position = "none") +
  labs(title="Halloween Candy PCA Space",
       subtitle="Colored by type: chocolate bar (dark brown), chocolate other (light brow
       caption="Data from 538")
```

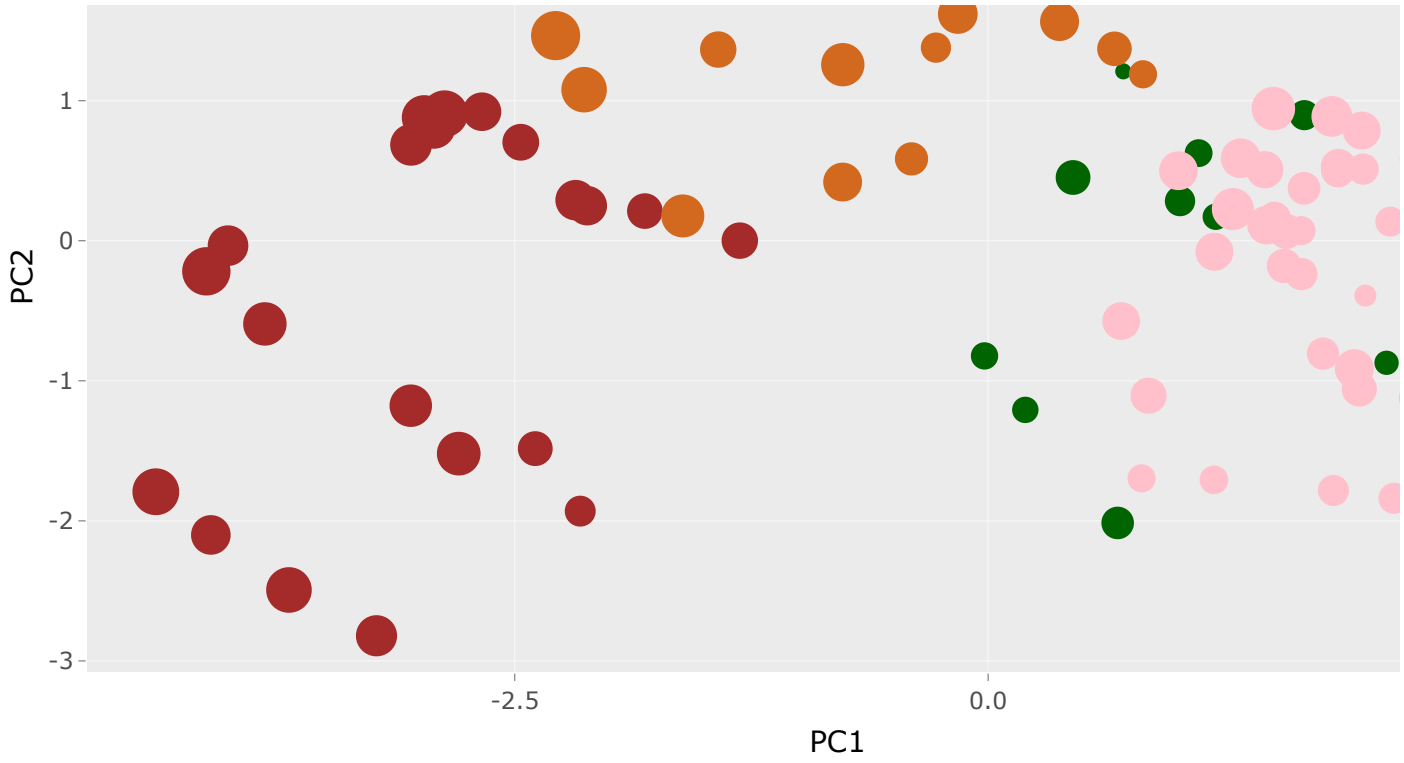
```
Warning: ggrepel: 39 unlabeled data points (too many overlaps). Consider
increasing max.overlaps
```




```
library(plotly)
```

```
Attaching package: 'plotly'

The following object is masked from 'package:ggplot2':

    last_plot

The following object is masked from 'package:stats':

    filter

The following object is masked from 'package:graphics':

    layout
```

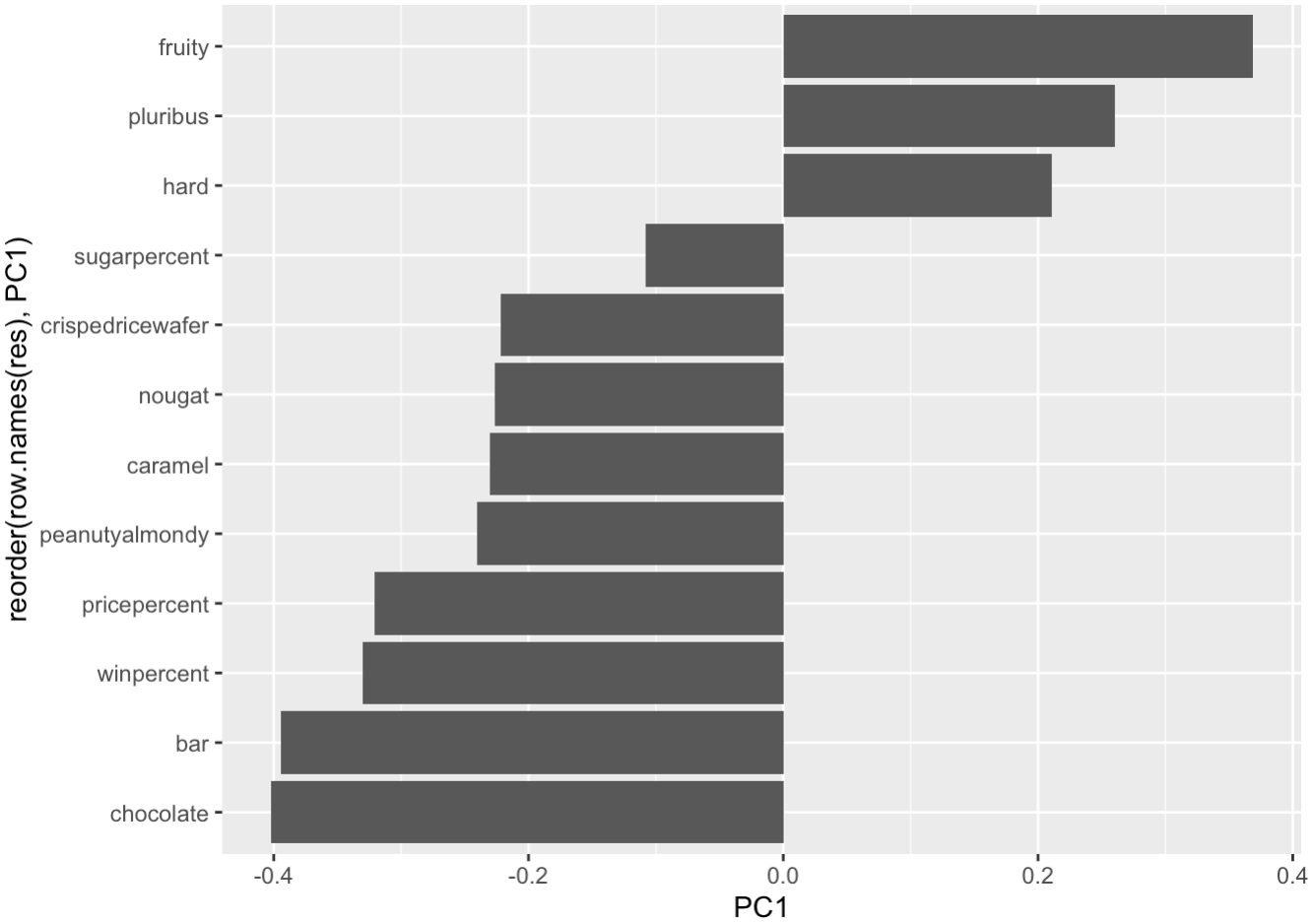
```
ggplotly(p)
```




```
pca$rotation[,1]
```

```
      chocolate           fruity          caramel   peanutyalmondy
     -0.4019466        0.3683883       -0.2299709       -0.2407155
         nougat crispedricewafer             hard              bar
     -0.2268102       -0.2215182        0.2111587       -0.3947433
       pluribus     sugarpercent     pricepercent       winpercent
      0.2600041       -0.1083088       -0.3207361       -0.3298035
```

```
res <- as.data.frame(pca$rotation)

ggplot(res) +
  aes(PC1, reorder(row.names(res), PC1)) +
geom_col()
```



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

Fruity, hard, and pluribus are all picked up strongly in the positive direction. This is correct because fruity candies are usually hard and come in variety.