Assignment-5

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Pre-processing the Data below:

```
Cereals <- read.csv("C:/Users/Harika/Downloads/Cereals.csv")
Cereals_Data <- read.csv("C:/Users/Harika/Downloads/Cereals.csv")
str(Cereals)
```

```
## 'data.frame':    77 obs. of  16 variables:
##  $ name    : chr  "100%_Bran" "100%_Natural_Bran" "All-Bran" "All-Bran_with_Extra_Fiber" ...
##  $ mfr     : chr  "N" "Q" "K" "K" ...
##  $ type    : chr  "C" "C" "C" "C" ...
##  $ calories: int  70 120 70 50 110 110 110 130 90 90 ...
##  $ protein : int  4 3 4 4 2 2 2 3 2 3 ...
##  $ fat     : int  1 5 1 0 2 2 0 2 1 0 ...
##  $ sodium  : int  130 15 260 140 200 180 125 210 200 210 ...
##  $ fiber   : num  10 2 9 14 1 1.5 1 2 4 5 ...
##  $ carbo   : num  5 8 7 8 14 10.5 11 18 15 13 ...
##  $ sugars  : int  6 8 5 0 8 10 14 8 6 5 ...
##  $ potass  : int  280 135 320 330 NA 70 30 100 125 190 ...
##  $ vitamins: int  25 0 25 25 25 25 25 25 25 25 ...
##  $ shelf   : int  3 3 3 3 3 1 2 3 1 3 ...
##  $ weight  : num  1 1 1 1 1 1 1 1.33 1 1 ...
##  $ cups    : num  0.33 1 0.33 0.5 0.75 0.75 1 0.75 0.67 0.67 ...
##  $ rating  : num  68.4 34 59.4 93.7 34.4 ...
```

```
### structure of the dataset.
```

```
head(Cereals)
```

```
##                        name mfr type calories protein fat sodium fiber carbo
## 1                 100%_Bran   N    C       70       4   1    130  10.0   5.0
## 2          100%_Natural_Bran   Q    C      120       3   5     15   2.0   8.0
## 3                   All-Bran   K    C       70       4   1    260   9.0   7.0
## 4 All-Bran_with_Extra_Fiber   K    C       50       4   0    140  14.0   8.0
## 5             Almond_Delight   R    C      110       2   2    200   1.0  14.0
## 6   Apple_Cinnamon_Cheerios   G    C      110       2   2    180   1.5  10.5
##   sugars potass vitamins shelf weight cups   rating
## 1      6    280       25     3      1 0.33 68.40297
## 2      8    135        0     3      1 1.00 33.98368
## 3      5    320       25     3      1 0.33 59.42551
## 4      0    330       25     3      1 0.50 93.70491
## 5      8     NA       25     3      1 0.75 34.38484
## 6     10     70       25     1      1 0.75 29.50954
```

```
### to display the first few rows and columns.
```

```
sum(is.na(Cereals))
```

```
## [1] 4
```

```
### to count the total no.of missing values.
```

```
Cereals <- na.omit(Cereals)
Cereals_Data <- na.omit(Cereals_Data)
### to omit the missing values from the given dataset.
sum(is.na(Cereals))
```

```
## [1] 0
```

```
rownames(Cereals) <- Cereals$name
rownames(Cereals_Data) <- Cereals_Data$name
### To convert breakfast cereal names to row names for visualizing the clusters later.
```

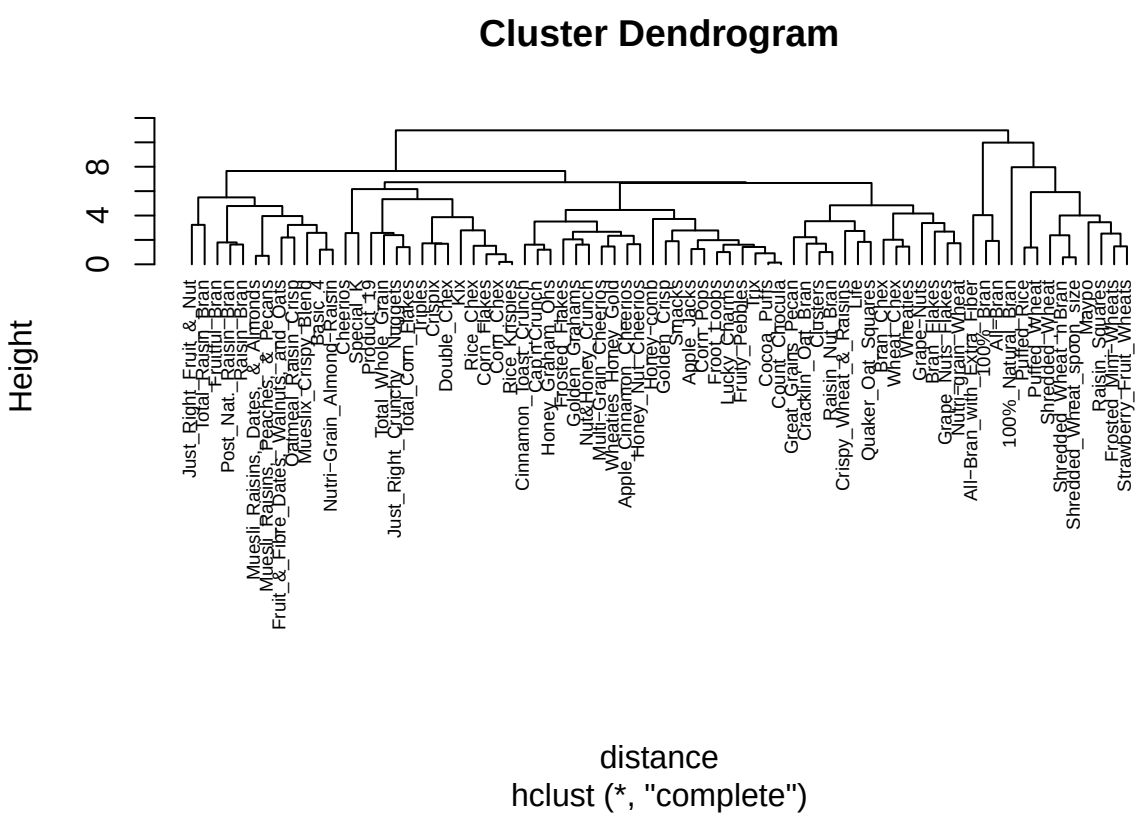
```
Cereals$name = NULL
Cereals_Data$name = NULL
### to remove the "name" column as it does not contain any information useful.
```

Before calculating any distance measure, it's essential to adjust the data. This is because variables with larger ranges can have a considerable impact on the distance calculation.

```
Cereals <- scale(Cereals[,3:15])
```

To do hierarchical clustering we used euclidean distance on the given dataset.

```
distance <- dist(Cereals, method = "euclidean")
#Dissimilarity matrix
hier_clust <- hclust(distance, method = "complete")
#applied hierarchical clustering using complete linkage.
plot(hier_clust, cex = 0.6, hang = -1)
```



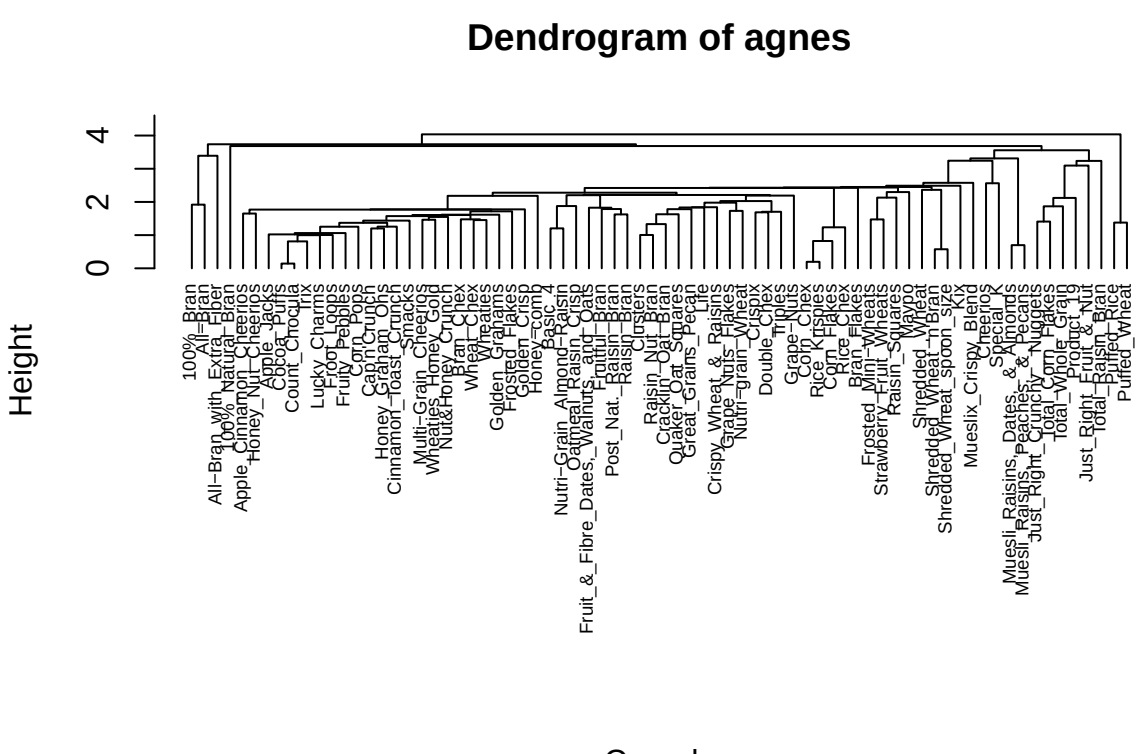

```
#to plot the dendrogram.
```

The clustering methods, such as single linkage, complete linkage, and average linkage, each have their own agglomerative coefficients.

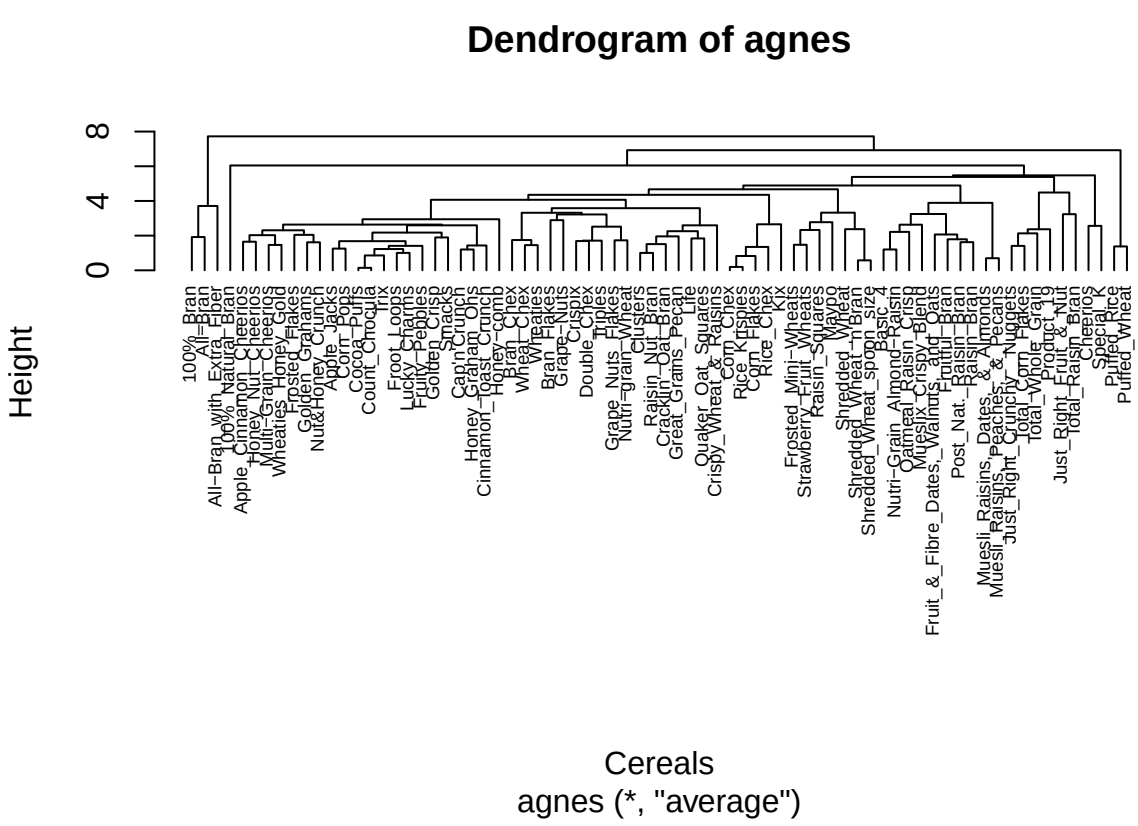
```
library(cluster)
```

```
## Warning: package 'cluster' was built under R version 4.3.2
```

```
hier_clust_single <- agnes(Cereals, method = "single")
pltree(hier_clust_single, cex = 0.6, hang = -1, main = " Dendrogram of agnes ")
```




```
hier_clust_avg <- agnes(Cereals, method = "average")
pltree(hier_clust_avg, cex = 0.6, hang = -1, main = " Dendrogram of agnes ")
```



To calculate the agnes coefficient for each approach.

```
#install.packages("purrr")
library(purrr)
```

```
## Warning: package 'purrr' was built under R version 4.3.2
```

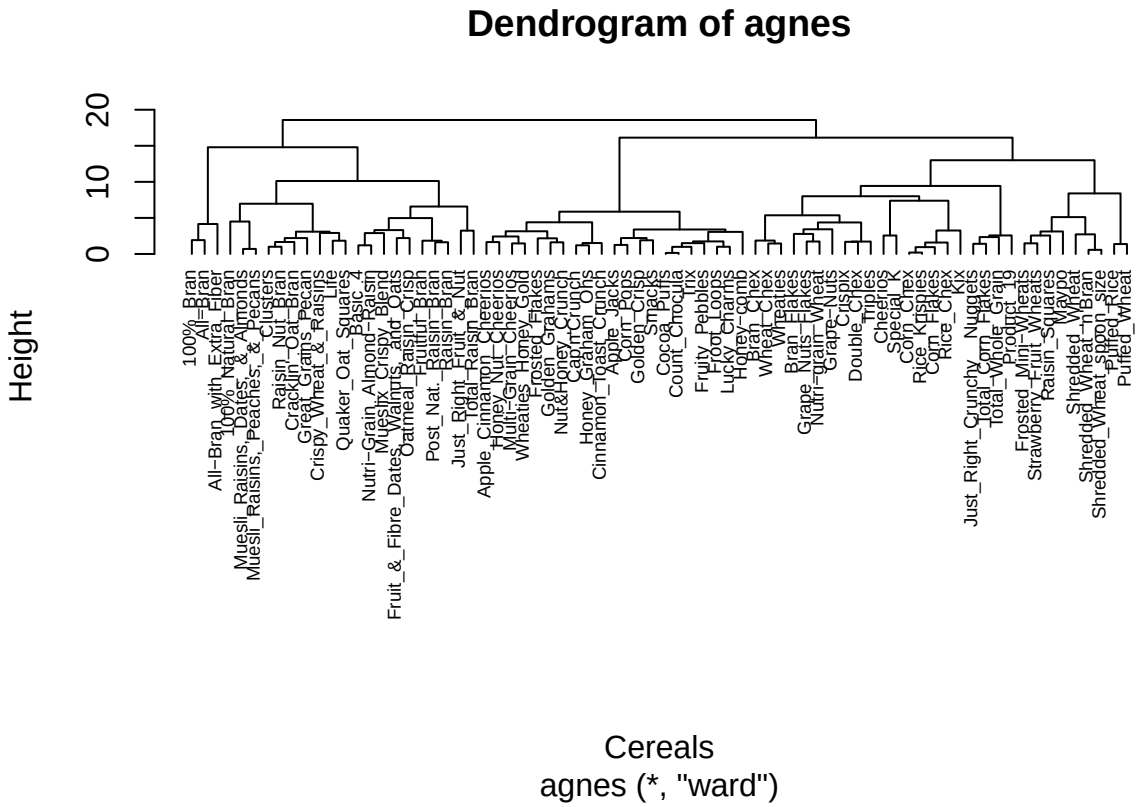
```
m <- c( "average", "single", "complete", "ward")
# to asses the methods.
names(m) <- c( "average", "single", "complete", "ward")
# here function is used to compute coefficient.
ac <- function(x) {
  agnes(Cereals, method = x)$ac
}
map_dbl(m, ac)
```

```
##   average    single  complete      ward
## 0.7766075 0.6067859 0.8353712 0.9046042
```

Ward is considered the most effective way to connect things, scoring a high 0.9046042 on the agglomerative coefficient.

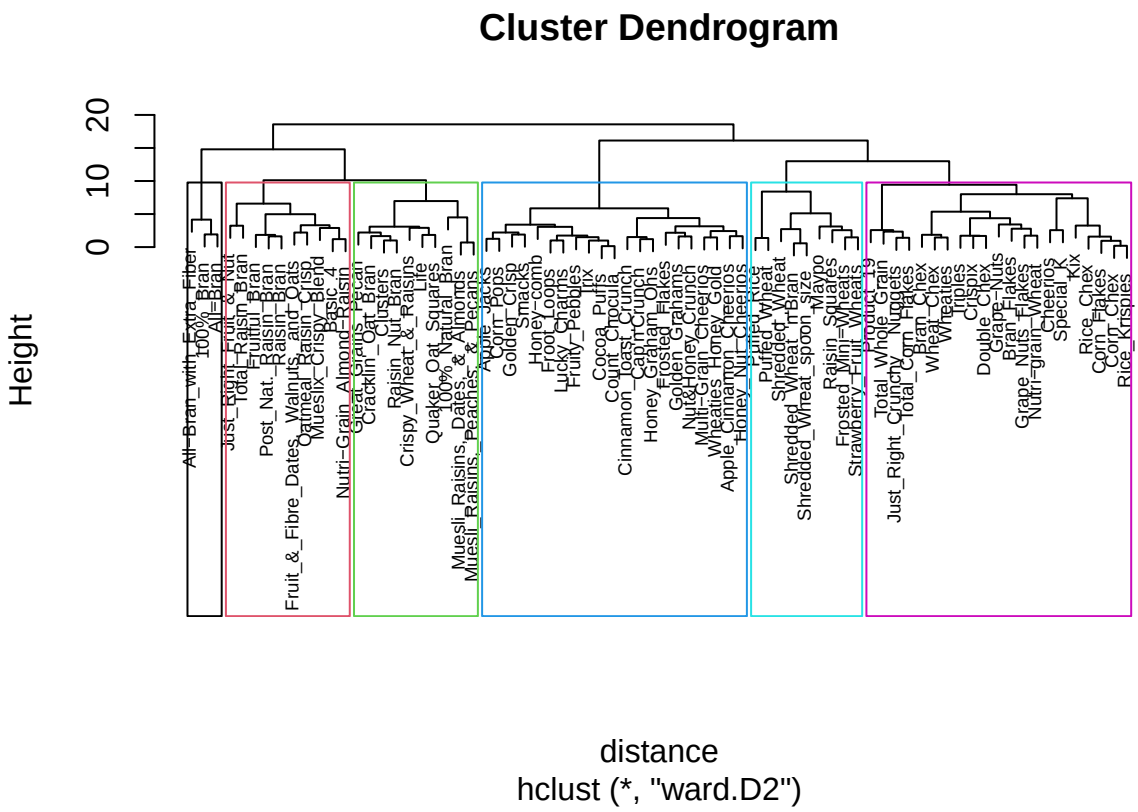
Using the wards approach to visualize the dendrogram:

```
hier_clust_Ward <- agnes(Cereals, method = "ward")
pltree(hier_clust_Ward, cex = 0.6, hang = -1, main = " Dendrogram of agnes ")
```



To Cut the dendrogram with cutree() so that we can find sub-groups (i.e. clusters):

```
distance <- dist(Cereals, method = "euclidean")
### to create the distance matrix.
hier_clust_Ward_clust <- hclust(distance, method = "ward.D2")
### ward's method for hierarchical clustering.
plot(hier_clust_Ward_clust, cex=0.6)
rect.hclust(hier_clust_Ward_clust, k=6, border = 1:6)
```



To examine how many data records have been categorized and that are allocated to clusters:

```
# to cut decision tree into 6 groups
sub_groups <- cutree(hier_clust_Ward_clust, k=6)
# total no.of members in each single cluster.
table(sub_groups)
```

```
## sub_groups
##  1  2  3  4  5  6
##  3 10 21 10 21  9
```

Correlation Matrix:

```
#install.packages("GGally")
library(GGally)
```

```
## Warning: package 'GGally' was built under R version 4.3.2

## Loading required package: ggplot2

## Warning: package 'ggplot2' was built under R version 4.3.2

## Registered S3 method overwritten by 'GGally':
##   method from
##   +.gg   ggplot2
```

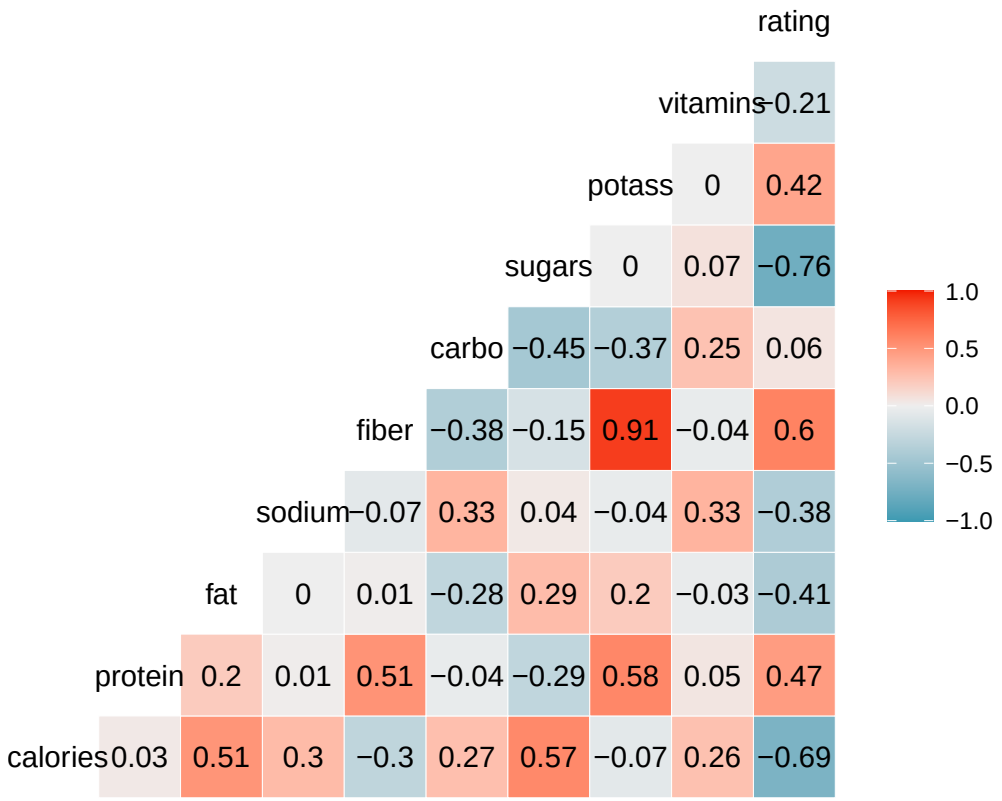
```r
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
Cereals_Data %>%
  select(calories, protein, fat, sodium, fiber, carbo, sugars, potass,vitamins,rating) %>%
  ggcorr(palette = "RdBu", label = TRUE, label_round =  2)
```



»The correlation matrix helps us figure out if there's a strong or weak connection between variables. It also allows us to calculate descriptive statistics for a better understanding.

The pvclust() function in the pvclust package helps assess the strength of clusters in hierarchical clustering using p-values from multiscale bootstrap resampling. Higher p-values indicate stronger support for clusters in the data. It's important to note that pvclust groups columns, so transpose your data before using the function. Suzuki provides guidance on interpreting the results.

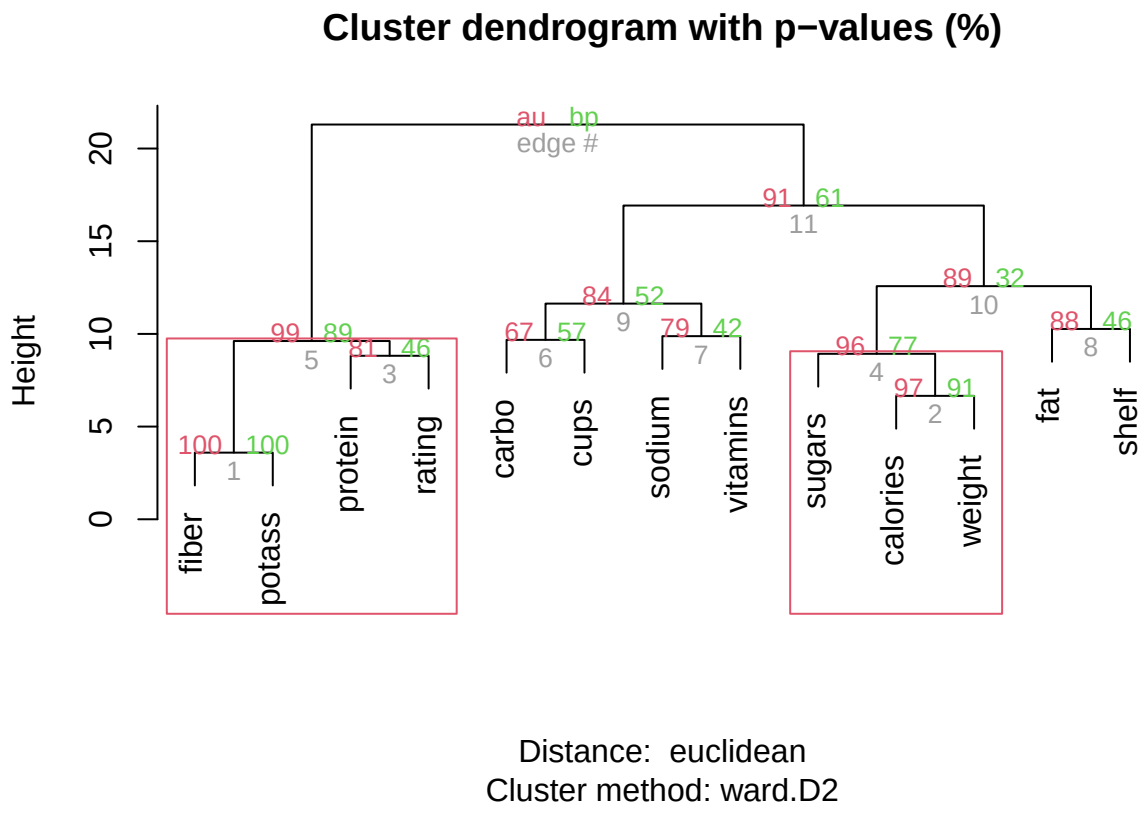
```
#install.packages("pvclust")
library(pvclust)
```

```
## Warning: package 'pvclust' was built under R version 4.3.2
```

```
fit.pv <- pvclust(Cereals, method.hclust = "ward.D2", method.dist = "euclidean")
```

```
## Bootstrap (r = 0.5)... Done.
## Bootstrap (r = 0.59)... Done.
## Bootstrap (r = 0.69)... Done.
## Bootstrap (r = 0.8)... Done.
## Bootstrap (r = 0.89)... Done.
## Bootstrap (r = 1.0)... Done.
## Bootstrap (r = 1.09)... Done.
## Bootstrap (r = 1.19)... Done.
## Bootstrap (r = 1.3)... Done.
## Bootstrap (r = 1.39)... Done.
```

```
plot(fit.pv)
#dendogram with p-values
pvrect(fit.pv, alpha =.95)
```



In the initial clustering, we assess how stable each cluster is by looking at the average Jaccard coefficient across multiple bootstrap iterations. If a cluster's

stability rating is below 0.6, it is considered unstable. Ratings between 0.6 and 0.75 suggest that the cluster identifies a pattern in the data, but there isn't strong agreement on which points should be grouped together. On the other hand, clusters with ratings above 0.85 are deemed exceptionally stable. 1.It's most effective to enhance the Jaccard bootstrap on a cluster level. 2.Minimize the occurrence of dissolved clusters, and aim to enhance the recovery of clusters while maintaining proximity to the original number.

To Run Clusterboot()

```
#install.packages("fpc")
library(fpc)
```

```
## Warning: package 'fpc' was built under R version 4.3.2
```

```
library(cluster)
kbest_p <- 6
cboot_hclust <- clusterboot(Cereals, clustermethod = hclustCBI, method = "ward.D2", k=kbest_p)
```

```
## boot 1
## boot 2
## boot 3
## boot 4
## boot 5
## boot 6
## boot 7
## boot 8
## boot 9
## boot 10
## boot 11
## boot 12
## boot 13
## boot 14
## boot 15
## boot 16
## boot 17
## boot 18
## boot 19
## boot 20
## boot 21
## boot 22
## boot 23
## boot 24
## boot 25
## boot 26
## boot 27
## boot 28
## boot 29
## boot 30
## boot 31
## boot 32
## boot 33
```

```
## boot 34
## boot 35
## boot 36
## boot 37
## boot 38
## boot 39
## boot 40
## boot 41
## boot 42
## boot 43
## boot 44
## boot 45
## boot 46
## boot 47
## boot 48
## boot 49
## boot 50
## boot 51
## boot 52
## boot 53
## boot 54
## boot 55
## boot 56
## boot 57
## boot 58
## boot 59
## boot 60
## boot 61
## boot 62
## boot 63
## boot 64
## boot 65
## boot 66
## boot 67
## boot 68
## boot 69
## boot 70
## boot 71
## boot 72
## boot 73
## boot 74
## boot 75
## boot 76
## boot 77
## boot 78
## boot 79
## boot 80
## boot 81
## boot 82
## boot 83
## boot 84
## boot 85
## boot 86
## boot 87
```

```
## boot 88
## boot 89
## boot 90
## boot 91
## boot 92
## boot 93
## boot 94
## boot 95
## boot 96
## boot 97
## boot 98
## boot 99
## boot 100
```

```
summary(cboot_hclust$result)
```

```
##               Length Class  Mode
## result         7     hclust list
## noise          1     -none- logical
## nc             1     -none- numeric
## clusterlist    6     -none- list
## partition     74     -none- numeric
## clustermethod  1     -none- character
## nccl           1     -none- numeric
```

```
groups <- cboot_hclust$result$partition
head(data.frame(groups))
```

```
##                            groups
## 100%_Bran                       1
## 100%_Natural_Bran               2
## All-Bran                        1
## All-Bran_with_Extra_Fiber       1
## Apple_Cinnamon_Cheerios         3
## Apple_Jacks                     3
```

```
cboot_hclust$bootmean
```

```
## [1] 0.8982067 0.4926056 0.9077396 0.6567419 0.6075877 0.6920081
```

```
### vector for cluster stabilities.
```

```
cboot_hclust$bootbrd
```

```
## [1] 11 68  0 35 31 37
```

```
### to Count how many times each group was broken apart. The clusterboot() function usually runs 100 bo
```

The findings suggest that Clusters 1 and 3 are quite reliable. However, Clusters 4 and 5 show some pattern recognition, but there's disagreement on which points should be grouped together. Clusters 2 and 5 are currently not stable.

To Extract the clusters found by hclust()

```
groups <- cutree(hier_clust_Ward_clust, k = 6)
print_cluster <- function(labels, k)
{
  for (i in 1:k)
    {
    print(paste("cluster",i))
    print(Cereals_Data[labels==i,c("mfr","calories","protein","fat","sodium","fiber","carbo","sugars","
  }
}
print_cluster(groups, 6)
```

```
## [1] "cluster 1"
##                            mfr calories protein fat sodium fiber carbo sugars
## 100%_Bran                    N       70       4   1    130    10     5      6
## All-Bran                     K       70       4   1    260     9     7      5
## All-Bran_with_Extra_Fiber    K       50       4   0    140    14     8      0
##                            potass vitamins   rating
## 100%_Bran                     280       25 68.40297
## All-Bran                      320       25 59.42551
## All-Bran_with_Extra_Fiber     330       25 93.70491
## [1] "cluster 2"
##                                  mfr calories protein fat sodium fiber carbo
## 100%_Natural_Bran                  Q      120       3   5     15   2.0   8.0
## Clusters                           G      110       3   2    140   2.0  13.0
## Cracklin'_Oat_Bran                 K      110       3   3    140   4.0  10.0
## Crispy_Wheat_&_Raisins             G      100       2   1    140   2.0  11.0
## Great_Grains_Pecan                 P      120       3   3     75   3.0  13.0
## Life                               Q      100       4   2    150   2.0  12.0
## Muesli_Raisins,_Dates,_&_Almonds   R      150       4   3     95   3.0  16.0
## Muesli_Raisins,_Peaches,_&_Pecans  R      150       4   3    150   3.0  16.0
## Quaker_Oat_Squares                 Q      100       4   1    135   2.0  14.0
## Raisin_Nut_Bran                    G      100       3   2    140   2.5  10.5
##                                  sugars potass vitamins   rating
## 100%_Natural_Bran                     8    135        0 33.98368
## Clusters                              7    105       25 40.40021
## Cracklin'_Oat_Bran                    7    160       25 40.44877
## Crispy_Wheat_&_Raisins               10    120       25 36.17620
## Great_Grains_Pecan                    4    100       25 45.81172
## Life                                  6     95       25 45.32807
## Muesli_Raisins,_Dates,_&_Almonds     11    170       25 37.13686
## Muesli_Raisins,_Peaches,_&_Pecans    11    170       25 34.13976
## Quaker_Oat_Squares                    6    110       25 49.51187
## Raisin_Nut_Bran                       8    140       25 39.70340
## [1] "cluster 3"
##                          mfr calories protein fat sodium fiber carbo sugars
## Apple_Cinnamon_Cheerios    G      110       2   2    180   1.5  10.5     10
## Apple_Jacks                K      110       2   0    125   1.0  11.0     14
## Cap'n'Crunch               Q      120       1   2    220   0.0  12.0     12
## Cinnamon_Toast_Crunch      G      120       1   3    210   0.0  13.0      9
## Cocoa_Puffs                G      110       1   1    180   0.0  12.0     13
## Corn_Pops                  K      110       1   0     90   1.0  13.0     12
## Count_Chocula              G      110       1   1    180   0.0  12.0     13
```

```
## Froot_Loops               K      110       2   1    125   1.0  11.0     13
## Frosted_Flakes            K      110       1   0    200   1.0  14.0     11
## Fruity_Pebbles            P      110       1   1    135   0.0  13.0     12
## Golden_Crisp              P      100       2   0     45   0.0  11.0     15
## Golden_Grahams            G      110       1   1    280   0.0  15.0      9
## Honey_Graham_Ohs          Q      120       1   2    220   1.0  12.0     11
## Honey_Nut_Cheerios        G      110       3   1    250   1.5  11.5     10
## Honey-comb                P      110       1   0    180   0.0  14.0     11
## Lucky_Charms              G      110       2   1    180   0.0  12.0     12
## Multi-Grain_Cheerios      G      100       2   1    220   2.0  15.0      6
## Nut&Honey_Crunch          K      120       2   1    190   0.0  15.0      9
## Smacks                    K      110       2   1     70   1.0   9.0     15
## Trix                      G      110       1   1    140   0.0  13.0     12
## Wheaties_Honey_Gold       G      110       2   1    200   1.0  16.0      8
##                         potass vitamins   rating
## Apple_Cinnamon_Cheerios     70       25 29.50954
## Apple_Jacks                 30       25 33.17409
## Cap'n'Crunch                35       25 18.04285
## Cinnamon_Toast_Crunch       45       25 19.82357
## Cocoa_Puffs                 55       25 22.73645
## Corn_Pops                   20       25 35.78279
## Count_Chocula               65       25 22.39651
## Froot_Loops                 30       25 32.20758
## Frosted_Flakes              25       25 31.43597
## Fruity_Pebbles              25       25 28.02576
## Golden_Crisp                40       25 35.25244
## Golden_Grahams              45       25 23.80404
## Honey_Graham_Ohs            45       25 21.87129
## Honey_Nut_Cheerios          90       25 31.07222
## Honey-comb                  35       25 28.74241
## Lucky_Charms                55       25 26.73451
## Multi-Grain_Cheerios        90       25 40.10596
## Nut&Honey_Crunch            40       25 29.92429
## Smacks                      40       25 31.23005
## Trix                        25       25 27.75330
## Wheaties_Honey_Gold         60       25 36.18756
## [1] "cluster 4"
##                                      mfr calories protein fat sodium fiber
## Basic_4                                G      130       3   2    210   2.0
## Fruit_&_Fibre_Dates,_Walnuts,_and_Oats P      120       3   2    160   5.0
## Fruitful_Bran                          K      120       3   0    240   5.0
## Just_Right_Fruit_&_Nut                 K      140       3   1    170   2.0
## Mueslix_Crispy_Blend                   K      160       3   2    150   3.0
## Nutri-Grain_Almond-Raisin              K      140       3   2    220   3.0
## Oatmeal_Raisin_Crisp                   G      130       3   2    170   1.5
## Post_Nat._Raisin_Bran                  P      120       3   1    200   6.0
## Raisin_Bran                            K      120       3   1    210   5.0
## Total_Raisin_Bran                      G      140       3   1    190   4.0
##                                      carbo sugars potass vitamins   rating
## Basic_4                               18.0      8    100       25 37.03856
## Fruit_&_Fibre_Dates,_Walnuts,_and_Oats 12.0     10    200       25 40.91705
## Fruitful_Bran                         14.0     12    190       25 41.01549
## Just_Right_Fruit_&_Nut                20.0      9     95      100 36.47151
## Mueslix_Crispy_Blend                  17.0     13    160       25 30.31335
```

```
## Nutri-Grain_Almond-Raisin              21.0      7    130       25 40.69232
## Oatmeal_Raisin_Crisp                   13.5     10    120       25 30.45084
## Post_Nat._Raisin_Bran                  11.0     14    260       25 37.84059
## Raisin_Bran                            14.0     12    240       25 39.25920
## Total_Raisin_Bran                      15.0     14    230      100 28.59278
## [1] "cluster 5"
##                              mfr calories protein fat sodium fiber carbo sugars
## Bran_Chex                      R       90       2   1    200     4    15      6
## Bran_Flakes                    P       90       3   0    210     5    13      5
## Cheerios                       G      110       6   2    290     2    17      1
## Corn_Chex                      R      110       2   0    280     0    22      3
## Corn_Flakes                    K      100       2   0    290     1    21      2
## Crispix                        K      110       2   0    220     1    21      3
## Double_Chex                    R      100       2   0    190     1    18      5
## Grape_Nuts_Flakes              P      100       3   1    140     3    15      5
## Grape-Nuts                     P      110       3   0    170     3    17      3
## Just_Right_Crunchy__Nuggets    K      110       2   1    170     1    17      6
## Kix                            G      110       2   1    260     0    21      3
## Nutri-grain_Wheat              K       90       3   0    170     3    18      2
## Product_19                     K      100       3   0    320     1    20      3
## Rice_Chex                      R      110       1   0    240     0    23      2
## Rice_Krispies                  K      110       2   0    290     0    22      3
## Special_K                      K      110       6   0    230     1    16      3
## Total_Corn_Flakes              G      110       2   1    200     0    21      3
## Total_Whole_Grain              G      100       3   1    200     3    16      3
## Triples                        G      110       2   1    250     0    21      3
## Wheat_Chex                     R      100       3   1    230     3    17      3
## Wheaties                       G      100       3   1    200     3    17      3
##                              potass vitamins   rating
## Bran_Chex                       125       25 49.12025
## Bran_Flakes                     190       25 53.31381
## Cheerios                        105       25 50.76500
## Corn_Chex                        25       25 41.44502
## Corn_Flakes                      35       25 45.86332
## Crispix                          30       25 46.89564
## Double_Chex                      80       25 44.33086
## Grape_Nuts_Flakes                85       25 52.07690
## Grape-Nuts                       90       25 53.37101
## Just_Right_Crunchy__Nuggets      60      100 36.52368
## Kix                              40       25 39.24111
## Nutri-grain_Wheat                90       25 59.64284
## Product_19                       45      100 41.50354
## Rice_Chex                        30       25 41.99893
## Rice_Krispies                    35       25 40.56016
## Special_K                        55       25 53.13132
## Total_Corn_Flakes                35      100 38.83975
## Total_Whole_Grain               110      100 46.65884
## Triples                          60       25 39.10617
## Wheat_Chex                      115       25 49.78744
## Wheaties                        110       25 51.59219
## [1] "cluster 6"
##                             mfr calories protein fat sodium fiber carbo sugars
## Frosted_Mini-Wheats           K      100       3   0      0     3    14      7
## Maypo                         A      100       4   1      0     0    16      3
```

```
## Puffed_Rice                 Q       50       1   0       0     0    13       0
## Puffed_Wheat                Q       50       2   0       0     1    10       0
## Raisin_Squares              K       90       2   0       0     2    15       6
## Shredded_Wheat              N       80       2   0       0     3    16       0
## Shredded_Wheat_'n'Bran      N       90       3   0       0     4    19       0
## Shredded_Wheat_spoon_size   N       90       3   0       0     3    20       0
## Strawberry_Fruit_Wheats     N       90       2   0      15     3    15       5
##                           potass vitamins   rating
## Frosted_Mini-Wheats          100       25 58.34514
## Maypo                         95       25 54.85092
## Puffed_Rice                   15        0 60.75611
## Puffed_Wheat                  50        0 63.00565
## Raisin_Squares               110       25 55.33314
## Shredded_Wheat                95        0 68.23588
## Shredded_Wheat_'n'Bran       140        0 74.47295
## Shredded_Wheat_spoon_size    120        0 72.80179
## Strawberry_Fruit_Wheats       90       25 59.36399
```

I chose clusters based on both statistical and nutritional values to create a healthy diet, but it's subjective as there's no clear measure for a healthy diet. I decided not to normalize the data to keep the original scale for better analysis. The cereal diet levels in the six clusters vary in richness, adequacy, and nutrient deficiencies. Cluster 1 has balanced guidelines, but limited options. Clusters 2 and 3 are not recommended due to poor ratings and high fat and sugar content. Clusters 4 and 5 have well-balanced nutrition and high consumer satisfaction, making them ideal for primary school cafeterias. So, for schools aiming to provide healthy meals, Clusters 4 and 5 are the best choices.