FML- Assignment-5

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```
# Loading requiered libraries
library(cluster)
library(caret)
```

```
## Loading required package: ggplot2
```

```
## Warning: package 'ggplot2' was built under R version 4.3.3
```

```
## Loading required package: lattice
```

```
library(dendextend)
```

```
## Warning: package 'dendextend' was built under R version 4.3.3
```

```
##
## ---------------------
## Welcome to dendextend version 1.17.1
## Type citation('dendextend') for how to cite the package.
##
## Type browseVignettes(package = 'dendextend') for the package vignette.
## The github page is: https://github.com/talgalili/dendextend/
##
## Suggestions and bug-reports can be submitted at: https://github.com/talgalili/dendextend/issues
## You may ask questions at stackoverflow, use the r and dendextend tags:
##   https://stackoverflow.com/questions/tagged/dendextend
##
##  To suppress this message use:  suppressPackageStartupMessages(library(dendextend))
## ---------------------
```

```
##
## Attaching package: 'dendextend'
```

```
## The following object is masked from 'package:stats':
##
##     cutree
```

```
library(knitr)
library(factoextra)
```

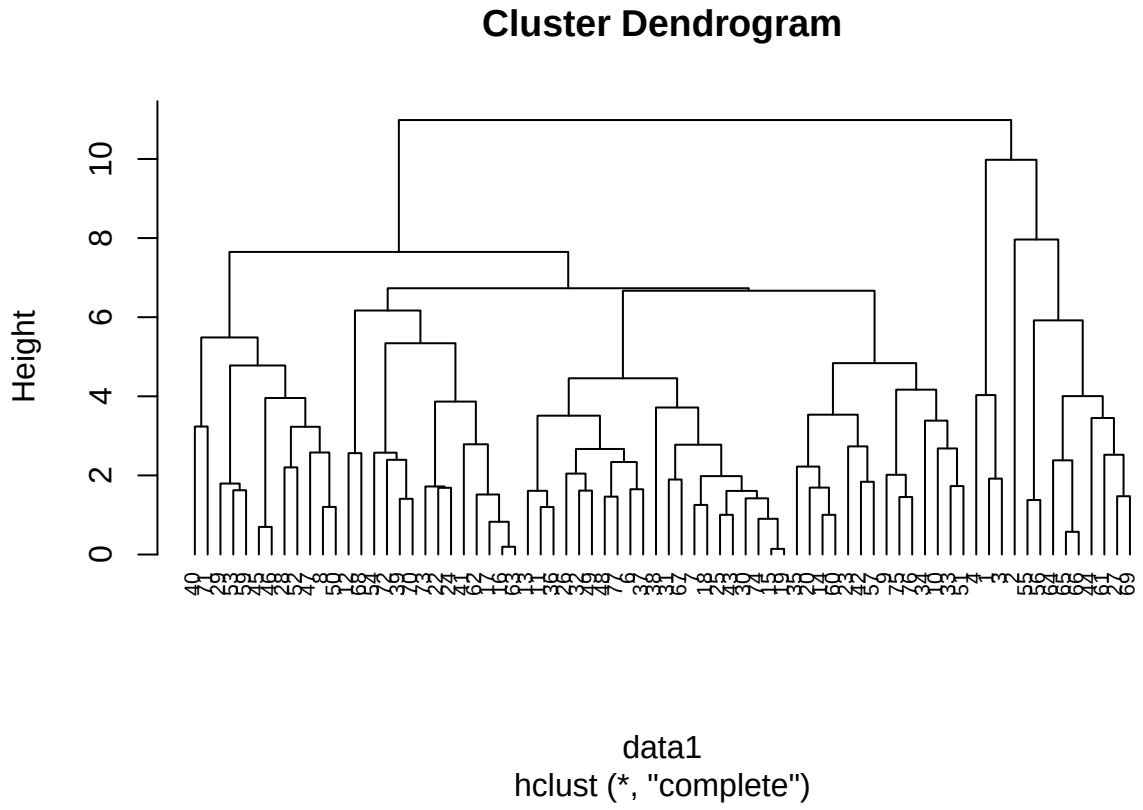
```
## Warning: package 'factoextra' was built under R version 4.3.3

## Welcome! Want to learn more? See two factoextra-related books at https://goo.gl/ve3WBa
```

```
library(readr)
```

```
#Importing dataset into R and creating a data collection which includes numbers
Cereals <- read.csv("Cereals.csv")
No_Cereals <- data.frame(Cereals[,4:16])
#Removing lacking values
No_Cereals <- na.omit(No_Cereals)
#Normalizing the data
Norm_Cereals <- scale(No_Cereals)
```

```
# Creating Hierarchical clustering using Euclidean distance technique
data1 <- dist(Norm_Cereals, method = "euclidean")
Hier_Clust <- hclust(data1, method = "complete")
#Plotting the dendogram
plot(Hier_Clust, cex = 0.7, hang = -1)
```




```
#Clustering with single linkage, full linkage,  Average linkage and Ward by using Agnes function and fi
Single_link <- agnes(Norm_Cereals, method = "single")
Complete_link <- agnes(Norm_Cereals, method = "complete")
Average_link <- agnes(Norm_Cereals, method = "average")
```

```r
Ward_link <- agnes(Norm_Cereals, method = "ward")
#printing each linkage
print(Single_link$ac)
```

```
## [1] 0.6067859
```

```r
print(Complete_link$ac)
```

```
## [1] 0.8353712
```

```r
print(Average_link$ac)
```

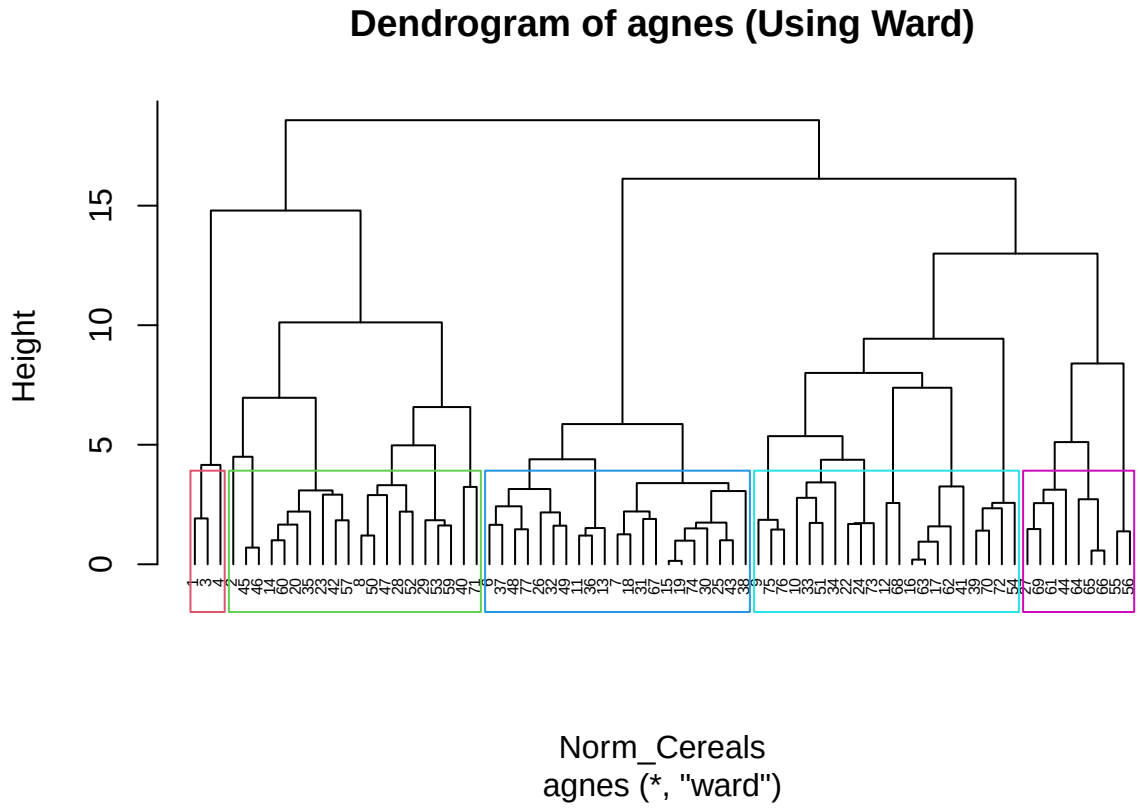
```
## [1] 0.7766075
```

```r
print(Ward_link$ac)
```

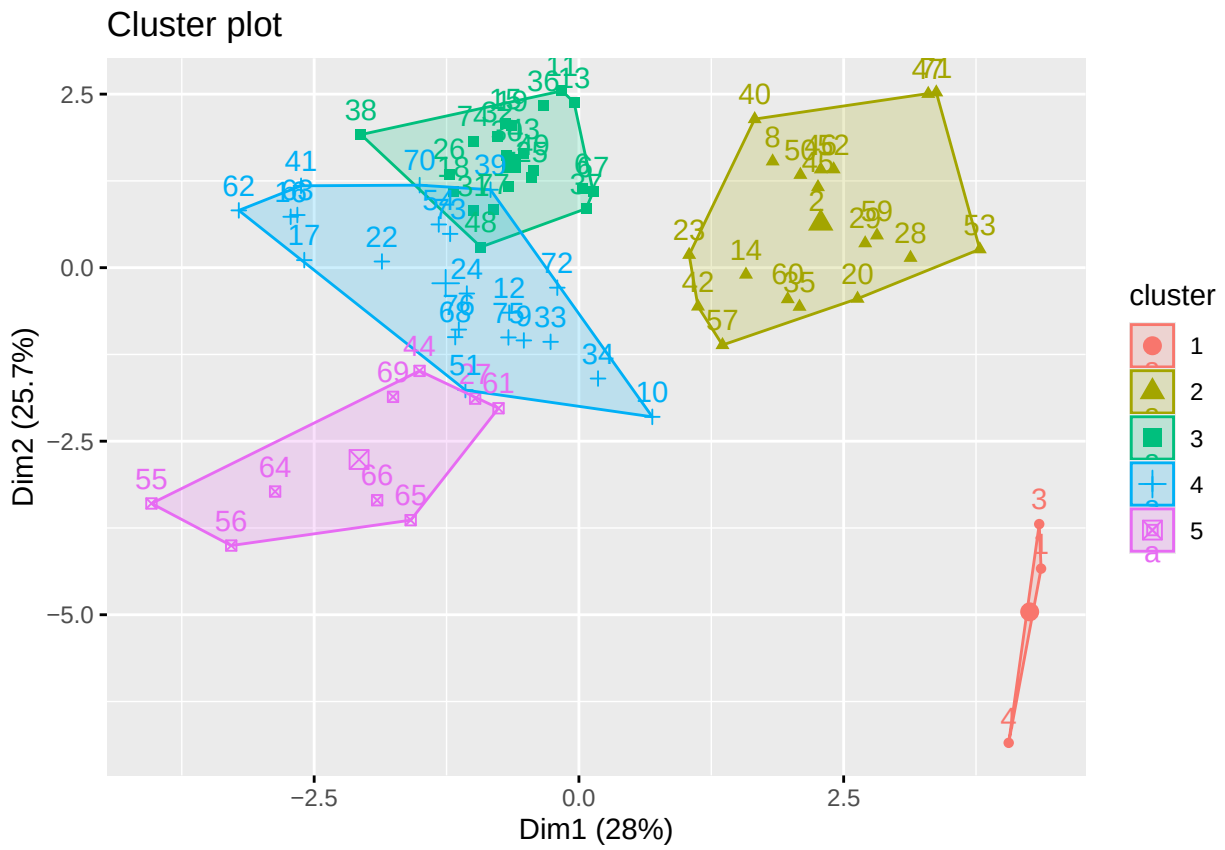
```
## [1] 0.9046042
```

By the above results we can say that the Ward strategy is the best method by it's value of 0.9046042 ## 2. Choosing the Clusters

```r
pltree(Ward_link, cex = 0.5, hang = -1, main = "Dendrogram of agnes (Using Ward)")
rect.hclust(Ward_link, k = 5, border = 2:7)
```



```
Group_1 <- cutree(Ward_link, k=5)
Frame_2 <- as.data.frame(cbind(Norm_Cereals,Group_1))
fviz_cluster(list(data = Frame_2, cluster = Group_1))
```

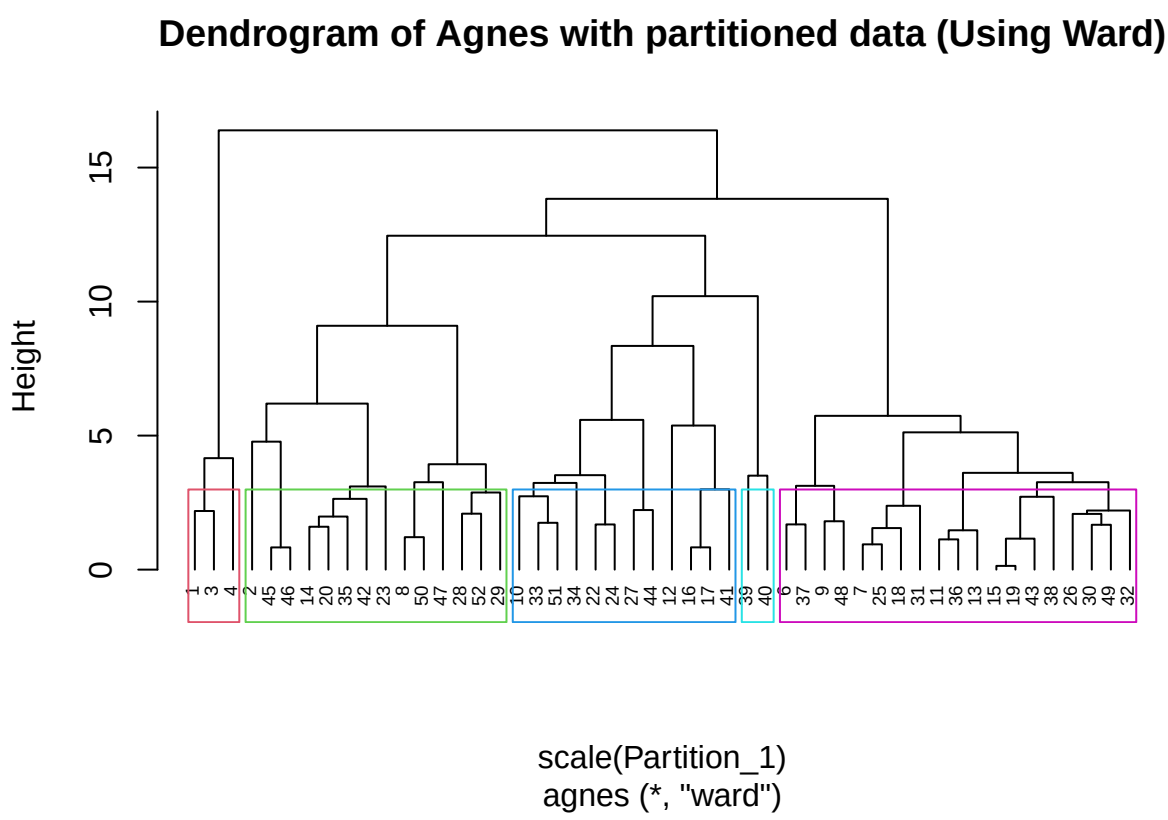


According to the above observation method, clusters can be selected.

```
# Partitioning
set.seed(333)
Partition_1 <- No_Cereals[1:50,]
Partition_2 <- No_Cereals[51:74,]
# Considering k=5
single_link_1 <- agnes(scale(Partition_1), method = "single")
complete_link_1 <- agnes(scale(Partition_1), method = "complete")
Average_link_1 <- agnes(scale(Partition_1), method = "average")
Ward_link_1 <- agnes(scale(Partition_1), method = "ward")
cbind(single=single_link_1$ac, complete = complete_link_1$ac, average = Average_link_1$ac, ward = Ward_l
```

```
##         single  complete   average      ward
## [1,] 0.6393338 0.8138238 0.7408904 0.8764323
```

```
pltree(Ward_link_1, cex = 0.6, hang = -1, main = "Dendrogram of Agnes with partitioned data (Using Ward
rect.hclust(Ward_link_1, k = 5, border = 2:7)
```




```
cut <- cutree(Ward_link_1, k = 5)
```

```
#Caluculating the centroids
result <- as.data.frame(cbind(Partition_1, cut))
result[result$cut==1,]
```

```
##   calories protein fat sodium fiber carbo sugars potass vitamins shelf weight
## 1       70       4   1    130    10     5       6    280       25     3      1
## 3       70       4   1    260     9     7       5    320       25     3      1
## 4       50       4   0    140    14     8       0    330       25     3      1
##   cups    rating cut
## 1 0.33 68.40297   1
## 3 0.33 59.42551   1
## 4 0.50 93.70491   1
```

```
Centroid_1 <- colMeans(result[result$cut==1,])
result[result$cut==2,]
```

```
##    calories protein fat sodium fiber carbo sugars potass vitamins shelf weight
## 2       120       3   5     15   2.0   8.0       8    135        0     3   1.00
## 8       130       3   2    210   2.0  18.0       8    100       25     3   1.33
## 14      110       3   2    140   2.0  13.0       7    105       25     3   1.00
## 20      110       3   3    140   4.0  10.0       7    160       25     3   1.00
## 23      100       2   1    140   2.0  11.0      10    120       25     3   1.00
```

```
## 28      120       3   2    160   5.0  12.0     10    200       25     3   1.25
## 29      120       3   0    240   5.0  14.0     12    190       25     3   1.33
## 35      120       3   3     75   3.0  13.0      4    100       25     3   1.00
## 42      100       4   2    150   2.0  12.0      6     95       25     2   1.00
## 45      150       4   3     95   3.0  16.0     11    170       25     3   1.00
## 46      150       4   3    150   3.0  16.0     11    170       25     3   1.00
## 47      160       3   2    150   3.0  17.0     13    160       25     3   1.50
## 50      140       3   2    220   3.0  21.0      7    130       25     3   1.33
## 52      130       3   2    170   1.5  13.5     10    120       25     3   1.25
##    cups   rating cut
## 2  1.00 33.98368   2
## 8  0.75 37.03856   2
## 14 0.50 40.40021   2
## 20 0.50 40.44877   2
## 23 0.75 36.17620   2
## 28 0.67 40.91705   2
## 29 0.67 41.01549   2
## 35 0.33 45.81172   2
## 42 0.67 45.32807   2
## 45 1.00 37.13686   2
## 46 1.00 34.13976   2
## 47 0.67 30.31335   2
## 50 0.67 40.69232   2
## 52 0.50 30.45084   2
```

```
Centroid_2 <- colMeans(result[result$cut==2,])
result[result$cut==3,]
```

```
##    calories protein fat sodium fiber carbo sugars potass vitamins shelf weight
## 6       110       2   2    180   1.5  10.5     10     70       25     1      1
## 7       110       2   0    125   1.0  11.0     14     30       25     2      1
## 9        90       2   1    200   4.0  15.0      6    125       25     1      1
## 11      120       1   2    220   0.0  12.0     12     35       25     2      1
## 13      120       1   3    210   0.0  13.0      9     45       25     2      1
## 15      110       1   1    180   0.0  12.0     13     55       25     2      1
## 18      110       1   0     90   1.0  13.0     12     20       25     2      1
## 19      110       1   1    180   0.0  12.0     13     65       25     2      1
## 25      110       2   1    125   1.0  11.0     13     30       25     2      1
## 26      110       1   0    200   1.0  14.0     11     25       25     1      1
## 30      110       1   1    135   0.0  13.0     12     25       25     2      1
## 31      100       2   0     45   0.0  11.0     15     40       25     1      1
## 32      110       1   1    280   0.0  15.0      9     45       25     2      1
## 36      120       1   2    220   1.0  12.0     11     45       25     2      1
## 37      110       3   1    250   1.5  11.5     10     90       25     1      1
## 38      110       1   0    180   0.0  14.0     11     35       25     1      1
## 43      110       2   1    180   0.0  12.0     12     55       25     2      1
## 48      100       2   1    220   2.0  15.0      6     90       25     1      1
## 49      120       2   1    190   0.0  15.0      9     40       25     2      1
##    cups   rating cut
## 6  0.75 29.50954   3
## 7  1.00 33.17409   3
## 9  0.67 49.12025   3
## 11 0.75 18.04285   3
## 13 0.75 19.82357   3
```

```
## 15 1.00 22.73645   3
## 18 1.00 35.78279   3
## 19 1.00 22.39651   3
## 25 1.00 32.20758   3
## 26 0.75 31.43597   3
## 30 0.75 28.02576   3
## 31 0.88 35.25244   3
## 32 0.75 23.80404   3
## 36 1.00 21.87129   3
## 37 0.75 31.07222   3
## 38 1.33 28.74241   3
## 43 1.00 26.73451   3
## 48 1.00 40.10596   3
## 49 0.67 29.92429   3
```

```
Centroid_3 <- colMeans(result[result$cut==3,])
result[result$cut==4,]
```

```
##    calories protein fat sodium fiber carbo sugars potass vitamins shelf weight
## 10       90       3   0    210     5    13       5    190       25     3      1
## 12      110       6   2    290     2    17       1    105       25     1      1
## 16      110       2   0    280     0    22       3     25       25     1      1
## 17      100       2   0    290     1    21       2     35       25     1      1
## 22      110       2   0    220     1    21       3     30       25     3      1
## 24      100       2   0    190     1    18       5     80       25     3      1
## 27      100       3   0      0     3    14       7    100       25     2      1
## 33      100       3   1    140     3    15       5     85       25     3      1
## 34      110       3   0    170     3    17       3     90       25     3      1
## 41      110       2   1    260     0    21       3     40       25     2      1
## 44      100       4   1      0     0    16       3     95       25     2      1
## 51       90       3   0    170     3    18       2     90       25     3      1
##    cups   rating cut
## 10 0.67 53.31381   4
## 12 1.25 50.76500   4
## 16 1.00 41.44502   4
## 17 1.00 45.86332   4
## 22 1.00 46.89564   4
## 24 0.75 44.33086   4
## 27 0.80 58.34514   4
## 33 0.88 52.07690   4
## 34 0.25 53.37101   4
## 41 1.50 39.24111   4
## 44 1.00 54.85092   4
## 51 1.00 59.64284   4
```

```
Centroid_4 <- colMeans(result[result$cut==4,])
Centroids <- rbind(Centroid_1, Centroid_2, Centroid_3, Centroid_4)
X <- as.data.frame(rbind(Centroids[,-14], Partition_2))
```

```
Distance <- get_dist(X)
Matrix <- as.matrix(Distance)
Dataframe_1 <- data.frame(data=seq(1,nrow(Partition_2), 1), Clusters = rep(0, nrow(Partition_2)))
for (i in 1:nrow(Partition_2))
```

```
{Dataframe_1[i,2] <- which.min(Matrix[i+4, 1:4])}
Dataframe_1
```

```
##    data Clusters
## 1     1        1
## 2     2        4
## 3     3        3
## 4     4        2
## 5     5        2
## 6     6        1
## 7     7        2
## 8     8        2
## 9     9        3
## 10   10        3
## 11   11        2
## 12   12        2
## 13   13        2
## 14   14        3
## 15   15        4
## 16   16        2
## 17   17        3
## 18   18        2
## 19   19        4
## 20   20        4
## 21   21        3
## 22   22        4
## 23   23        4
## 24   24        3
```

```
cbind(Frame_2$Group_1[51:74], Dataframe_1$Clusters)
```

```
##       [,1] [,2]
##  [1,]    2    1
##  [2,]    4    4
##  [3,]    5    3
##  [4,]    5    2
##  [5,]    2    2
##  [6,]    2    1
##  [7,]    2    2
##  [8,]    5    2
##  [9,]    4    3
## [10,]    4    3
## [11,]    5    2
## [12,]    5    2
## [13,]    5    2
## [14,]    3    3
## [15,]    4    4
## [16,]    5    2
## [17,]    4    3
## [18,]    2    2
## [19,]    4    4
## [20,]    4    4
```

```
## [21,]    3    3
## [22,]    4    4
## [23,]    4    4
## [24,]    3    3
```

```
table(Frame_2$Group_1[51:74] == Dataframe_1$Clusters)
```

```
##
## FALSE  TRUE
##    12    12
```

We can see that the observations are 12 true and 12 false, by this we can claim that the model in partially unstable. ## 3) The elementary public schools would like to choose a set of Cereals to include in their daily cafeterias. Every day a different cereal is offered, but all Cereals should support a healthy diet. For this goal, you are requested to find a cluster of "healthyCereals''

```
Healthy_Cereals <- Cereals
Healthy_Cereals_1 <- na.omit(Healthy_Cereals)
clustering <- cbind(Healthy_Cereals_1, Group_1)
clustering[clustering$Group_1==1,]
```

```
##                         name mfr type calories protein fat sodium fiber carbo
## 1                  100%_Bran   N    C       70       4   1    130    10     5
## 3                   All-Bran   K    C       70       4   1    260     9     7
## 4 All-Bran_with_Extra_Fiber   K    C       50       4   0    140    14     8
##   sugars potass vitamins shelf weight cups   rating Group_1
## 1      6    280       25     3      1 0.33 68.40297       1
## 3      5    320       25     3      1 0.33 59.42551       1
## 4      0    330       25     3      1 0.50 93.70491       1
```

```
clustering[clustering$Group_1==2,]
```

```
##                                     name mfr type calories protein fat sodium
## 2                    100%_Natural_Bran   Q    C      120       3   5     15
## 8                              Basic_4   G    C      130       3   2    210
## 14                            Clusters   G    C      110       3   2    140
## 20                  Cracklin'_Oat_Bran   K    C      110       3   3    140
## 23                Crispy_Wheat_&_Raisins   G    C      100       2   1    140
## 28 Fruit_&_Fibre_Dates,_Walnuts,_and_Oats   P    C      120       3   2    160
## 29                         Fruitful_Bran   K    C      120       3   0    240
## 35                   Great_Grains_Pecan   P    C      120       3   3     75
## 40                Just_Right_Fruit_&_Nut   K    C      140       3   1    170
## 42                                  Life   Q    C      100       4   2    150
## 45       Muesli_Raisins,_Dates,_&_Almonds   R    C      150       4   3     95
## 46      Muesli_Raisins,_Peaches,_&_Pecans   R    C      150       4   3    150
## 47                  Mueslix_Crispy_Blend   K    C      160       3   2    150
## 50              Nutri-Grain_Almond-Raisin   K    C      140       3   2    220
## 52                   Oatmeal_Raisin_Crisp   G    C      130       3   2    170
## 53                 Post_Nat._Raisin_Bran   P    C      120       3   1    200
## 57                    Quaker_Oat_Squares   Q    C      100       4   1    135
## 59                          Raisin_Bran   K    C      120       3   1    210
## 60                     Raisin_Nut_Bran   G    C      100       3   2    140
```

```
## 71                    Total_Raisin_Bran   G    C      140       3   1    190
##    fiber carbo sugars potass vitamins shelf weight cups   rating Group_1
## 2    2.0   8.0      8    135        0     3   1.00 1.00 33.98368       2
## 8    2.0  18.0      8    100       25     3   1.33 0.75 37.03856       2
## 14   2.0  13.0      7    105       25     3   1.00 0.50 40.40021       2
## 20   4.0  10.0      7    160       25     3   1.00 0.50 40.44877       2
## 23   2.0  11.0     10    120       25     3   1.00 0.75 36.17620       2
## 28   5.0  12.0     10    200       25     3   1.25 0.67 40.91705       2
## 29   5.0  14.0     12    190       25     3   1.33 0.67 41.01549       2
## 35   3.0  13.0      4    100       25     3   1.00 0.33 45.81172       2
## 40   2.0  20.0      9     95      100     3   1.30 0.75 36.47151       2
## 42   2.0  12.0      6     95       25     2   1.00 0.67 45.32807       2
## 45   3.0  16.0     11    170       25     3   1.00 1.00 37.13686       2
## 46   3.0  16.0     11    170       25     3   1.00 1.00 34.13976       2
## 47   3.0  17.0     13    160       25     3   1.50 0.67 30.31335       2
## 50   3.0  21.0      7    130       25     3   1.33 0.67 40.69232       2
## 52   1.5  13.5     10    120       25     3   1.25 0.50 30.45084       2
## 53   6.0  11.0     14    260       25     3   1.33 0.67 37.84059       2
## 57   2.0  14.0      6    110       25     3   1.00 0.50 49.51187       2
## 59   5.0  14.0     12    240       25     2   1.33 0.75 39.25920       2
## 60   2.5  10.5      8    140       25     3   1.00 0.50 39.70340       2
## 71   4.0  15.0     14    230      100     3   1.50 1.00 28.59278       2
```

```
clustering[clustering$Group_1==3,]
```

```
##                       name mfr type calories protein fat sodium fiber carbo
## 6  Apple_Cinnamon_Cheerios   G    C      110       2   2    180   1.5  10.5
## 7              Apple_Jacks   K    C      110       2   0    125   1.0  11.0
## 11           Cap'n'Crunch   Q    C      120       1   2    220   0.0  12.0
## 13  Cinnamon_Toast_Crunch   G    C      120       1   3    210   0.0  13.0
## 15             Cocoa_Puffs   G    C      110       1   1    180   0.0  12.0
## 18               Corn_Pops   K    C      110       1   0     90   1.0  13.0
## 19           Count_Chocula   G    C      110       1   1    180   0.0  12.0
## 25             Froot_Loops   K    C      110       2   1    125   1.0  11.0
## 26          Frosted_Flakes   K    C      110       1   0    200   1.0  14.0
## 30          Fruity_Pebbles   P    C      110       1   1    135   0.0  13.0
## 31            Golden_Crisp   P    C      100       2   0     45   0.0  11.0
## 32          Golden_Grahams   G    C      110       1   1    280   0.0  15.0
## 36        Honey_Graham_Ohs   Q    C      120       1   2    220   1.0  12.0
## 37      Honey_Nut_Cheerios   G    C      110       3   1    250   1.5  11.5
## 38              Honey-comb   P    C      110       1   0    180   0.0  14.0
## 43            Lucky_Charms   G    C      110       2   1    180   0.0  12.0
## 48   Multi-Grain_Cheerios   G    C      100       2   1    220   2.0  15.0
## 49        Nut&Honey_Crunch   K    C      120       2   1    190   0.0  15.0
## 67                  Smacks   K    C      110       2   1     70   1.0   9.0
## 74                    Trix   G    C      110       1   1    140   0.0  13.0
## 77     Wheaties_Honey_Gold   G    C      110       2   1    200   1.0  16.0
##    sugars potass vitamins shelf weight cups   rating Group_1
## 6      10     70       25     1      1 0.75 29.50954       3
## 7      14     30       25     2      1 1.00 33.17409       3
## 11     12     35       25     2      1 0.75 18.04285       3
## 13      9     45       25     2      1 0.75 19.82357       3
## 15     13     55       25     2      1 1.00 22.73645       3
## 18     12     20       25     2      1 1.00 35.78279       3
```

```
## 19     13     65       25     2      1 1.00 22.39651       3
## 25     13     30       25     2      1 1.00 32.20758       3
## 26     11     25       25     1      1 0.75 31.43597       3
## 30     12     25       25     2      1 0.75 28.02576       3
## 31     15     40       25     1      1 0.88 35.25244       3
## 32      9     45       25     2      1 0.75 23.80404       3
## 36     11     45       25     2      1 1.00 21.87129       3
## 37     10     90       25     1      1 0.75 31.07222       3
## 38     11     35       25     1      1 1.33 28.74241       3
## 43     12     55       25     2      1 1.00 26.73451       3
## 48      6     90       25     1      1 1.00 40.10596       3
## 49      9     40       25     2      1 0.67 29.92429       3
## 67     15     40       25     2      1 0.75 31.23005       3
## 74     12     25       25     2      1 1.00 27.75330       3
## 77      8     60       25     1      1 0.75 36.18756       3
```

```
clustering[clustering$Group_1==4,]
```

```
##                         name mfr type calories protein fat sodium fiber carbo
## 9                  Bran_Chex   R    C       90       2   1    200     4    15
## 10                Bran_Flakes   P    C       90       3   0    210     5    13
## 12                   Cheerios   G    C      110       6   2    290     2    17
## 16                  Corn_Chex   R    C      110       2   0    280     0    22
## 17                Corn_Flakes   K    C      100       2   0    290     1    21
## 22                    Crispix   K    C      110       2   0    220     1    21
## 24                Double_Chex   R    C      100       2   0    190     1    18
## 33          Grape_Nuts_Flakes   P    C      100       3   1    140     3    15
## 34                 Grape-Nuts   P    C      110       3   0    170     3    17
## 39 Just_Right_Crunchy__Nuggets   K    C      110       2   1    170     1    17
## 41                        Kix   G    C      110       2   1    260     0    21
## 51          Nutri-grain_Wheat   K    C       90       3   0    170     3    18
## 54                 Product_19   K    C      100       3   0    320     1    20
## 62                  Rice_Chex   R    C      110       1   0    240     0    23
## 63              Rice_Krispies   K    C      110       2   0    290     0    22
## 68                  Special_K   K    C      110       6   0    230     1    16
## 70          Total_Corn_Flakes   G    C      110       2   1    200     0    21
## 72          Total_Whole_Grain   G    C      100       3   1    200     3    16
## 73                    Triples   G    C      110       2   1    250     0    21
## 75                 Wheat_Chex   R    C      100       3   1    230     3    17
## 76                   Wheaties   G    C      100       3   1    200     3    17
##    sugars potass vitamins shelf weight cups   rating Group_1
## 9       6    125       25     1      1 0.67 49.12025       4
## 10      5    190       25     3      1 0.67 53.31381       4
## 12      1    105       25     1      1 1.25 50.76500       4
## 16      3     25       25     1      1 1.00 41.44502       4
## 17      2     35       25     1      1 1.00 45.86332       4
## 22      3     30       25     3      1 1.00 46.89564       4
## 24      5     80       25     3      1 0.75 44.33086       4
## 33      5     85       25     3      1 0.88 52.07690       4
## 34      3     90       25     3      1 0.25 53.37101       4
## 39      6     60      100     3      1 1.00 36.52368       4
## 41      3     40       25     2      1 1.50 39.24111       4
## 51      2     90       25     3      1 1.00 59.64284       4
## 54      3     45      100     3      1 1.00 41.50354       4
```

```
## 62      2     30       25     1      1 1.13 41.99893       4
## 63      3     35       25     1      1 1.00 40.56016       4
## 68      3     55       25     1      1 1.00 53.13132       4
## 70      3     35      100     3      1 1.00 38.83975       4
## 72      3    110      100     3      1 1.00 46.65884       4
## 73      3     60       25     3      1 0.75 39.10617       4
## 75      3    115       25     1      1 0.67 49.78744       4
## 76      3    110       25     1      1 1.00 51.59219       4
```

```
#Selecting the best cluster
mean(clustering[clustering$Group_1==1, "rating"])
```

```
## [1] 73.84446
```

```
mean(clustering[clustering$Group_1==2, "rating"])
```

```
## [1] 38.26161
```

```
mean(clustering[clustering$Group_1==3, "rating"])
```

```
## [1] 28.84825
```

```
mean(clustering[clustering$Group_1==4, "rating"])
```

```
## [1] 46.46513
```

Cluster 1 is the best cluster since it is the highest. So, Group1 may be considered as the cluster for a healthy diet. Normalizing may not be necessary. We can use the raw ratings for the cluster analysis if the ratings are on a consistent scale and there are no additional variables that use different scales or units. In this instance, a clustering technique may be used directly on these values to group similar cereals together based on ratings. Each cereal can be represented by its rating value. In summary, we can utilize the ratings straight into the cluster analysis without the need for normalization if they are already on a comparable scale. The rating value of each cereal would serve as its representation, and cereals with comparable ratings might be grouped together using clustering algorithms.