POPCORN TO DETERMINE THE BRAND WITH THE MOST POP KERNELS.

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ABSTRACT.

The purpose of this experiment was to see which brand of popcorn kernel popped the most. This data would be needed to see which type of popcorn is the most reliable when it is being made for big events or groups. In the experiment, 1 pre-weighed sealed popcorn kernel bag for every brand of popcorn was selected. The paper bags were put in a microwave separately from the other brands at different times and power levels, and were cooked alternating time on short and long and power on high and low respectively. After the popcorn finished popping the popcorn kernels was measured in litres using graduated bowl to get the volume of the popped kernels. The Orville Redenbacher's popcorn ended up popping the most, but the pop weaver brand popcorn was only a few kernels below by a small volume. Orville Redenbacher considered brand A was more expensive than Pop weaver considered as brand B.

INTRODUCTION

  Popcorn kernels are made out of several layers. Popcorn kernels have a hard-outer shell that holds in the popcorns starchy white center and liquid content. The layers of popcorn have names.

The outer shell is the pericarp, which protects the stuff inside. The starchy white interior is called the endosperm. The moist part is called the germ and the tip or tips are called the tip cap. 13% of a popcorn kernel is the moist part in the center. Every popcorn kernel has a certain amount of oil and moisture inside of it. Unlike most grains, popcorn has a hard-outer shell that's impervious to moisture. The starch is hard and dense. Popcorn kernels are made out of the same thing, but there are two different types of kernels that look different. Rice popcorn has a pointed angle at each end of the kernel and "pearl popcorn" is circular. Kernels of popcorn can be cooked in different ways, through popcorn machines, microwave or stove. When the popcorn kernels are heated up to about 204 C the moist, wet interior begins to evaporate and processed into steam, which is a gas. A gas needs more space than a liquid, so when the liquid would have just enough space, the gas does

not and tries to expand. The expanding of the gas releases pressure inside the shell. When the pressure is great enough, the pressure breaks the shell trying to get out, and then the popcorn explodes. When it explodes it turns into a fluffy morsel, of popcorn.

There are many experiments carried out on popcorn, but each experiment has been to ascertain one thing or the other. We found out that some two students namely Niki Vila Boas and cade Spector both of Cary Academy carried out a similar experiment to ours. Niki's experiments was if soaked popcorn, would the popping efficiency still be the same if soaked for different times and her other experiment was if yellow or white popcorn pop different amounts of popcorn. Popcorn has been around for a while, over thousands of years. It was founded by Guatemalans. In Africa, we believe that Popcorn comes from America and it is a special desert during occasions like birthdays, wedding ceremonies and Christmas. It is today being processed locally by rural farmers who get the seed breed from Agricultural shows. White farmers in South Africa and Zimbabwe do produce in large scale. Archeologists found popcorn being around from 3600 BCE in Mexico, and even early like 4700 BCE in Peru. When the English came to America, they learned about popcorn from the Native Americans who were already inhabited. Popcorn was most used during the Great Depression. While most businesses fell, popcorn began to thrive while being at the cost of 5-10 cents a bag, making it affordable during the money crisis. It began to become a source of income for many struggling farmers. They put their attention to making corn for popping and it became a very important crop during the time Again it began big during World War 2 when sugar candies were diminished due to sugar rations. Due to this, people started eating almost 3 times the amount of popcorn that they used to because instead of candy, they eat popcorn.

MATERIALS AND DESIGN

 Pre- weighed and sealed Pop weaver and Orville Popcorn Redenbacher, a graduated bowl, and a microwave were used in this experiment. 1 pre-weighed and sealed bag of each brand of popcorn was placed in the microwave for Short (90s) and Long(105secs),and Power on High(10) and low(9) respectively.

Our experiment is a factorial design with three factors, Brand, Time and Power. We are using two brands of the popcorn kernels as stated above with 2 levels of each factor making a 2^3 factorial design with our numerator degree of freedom as

1 since we only have two brands and for time and power will be 1. For each of those brands, we decided to run two replicates per cell to enable us to get a power of about 90% and above to detect a standard error of 0.1 as shown in the code and output of SAS below.

```
data Power;
do r=2 to 6;
   nu1=2-1;
   nu2=4*(r-1);
   alpha=0.05;
   Fcrit=finv(1-
alpha,nu1,nu2);
   sigma=0.1;
   css=2;
   nc=r*(css)/sigma;
   power=1-probf(Fcrit,nu1,nu2,nc);
   output;
end;
keep r nu1 nu2 nc power;
title power Calculation in data steps;
proc print;
run;
```

Obs	r	nu1	nu2	nc	power
1	2	1	4	40	0.99504
2	3	1	8	60	1.00000
3	4	1	12	80	1.00000
4	5	1	16	100	1.00000
5	6	1	20	120	1.00000

Two levels of popcorn Brand, and two levels of both Power and the time the popcorn is left in the microwave was randomized in SAS with two replicates to get the runs for the experiment as shown below:

```
proc factex ;
 factors Time Power ;
 output out = TP Time cvals =( ' Short ' ' Long ')
 Power cvals =( ' Low ' ' High ');
 run ;
 factors Brand / nlev =2;
 output out = popcorn designrep =2 pointrep = TP
```

```
 Brand cvals =( ' Brand A ' ' Brand B ') ;
data popcorn ; set popcorn ;
 u= ranuni (0) ;
 proc sort ; by u;
 proc print ; var Time Power Brand ; run ;
```

Obs	Time	Power	Brand
1	Short	Low	Brand A
2	Long	Low	Brand A
3	Long	High	Brand B
4	Long	High	Brand A
5	Short	High	Brand A
6	Short	High	Brand A
7	Long	Low	Brand B
8	Short	Low	Brand B
9	Long	Low	Brand A
10	Short	Low	Brand B
11	Short	High	Brand B
12	Short	Low	Brand A
13	Long	Low	Brand B
14	Short	High	Brand B
15	Long	High	Brand B
16	Long	High	Brand A

Data Collection.

The popped popcorn was placed in the graduated measuring bowl to show how much popcorn popped. The routine was repeated 16 times for each brand and then the values were recorded. The volume of each popcorn popped was recorded for the two different brands and were compared to see which brand popped the most popcorn I bag of Orville Redenbacher Popcorn kernels were placed in a microwave for different amounts of time. The times the popcorn was cooked for were short (90 sec) and long(105sec) sixteen times each. When the Orville popcorn was finished popping, the amount of popcorn kernels popped where recorded. After sixteen trials of each of the times, the volume was recorded for each and compared against each other.

Popcorn Experiment

EXPERIMENTAL PHOTOS

Data Analysis

Our analysis was done using the SAS software.

```
data popcorn;
    input Time$Power$Brand$Volume;
 datalines;
 -1 -1 B  1.6
 -1 -1 B 1.3
 1 -1 A  1.8
 -1 1 A 1.9
 -1 -1 A 1.7
 1 1 B 1.7
 -1 1 B 1.6
 1 -1 A 2.0
 1 1 A 2.5
 -1 -1 A 1.8
 -1 1 A 2.0
  1 1 B 1.6
  1 -1 A 1.7
  1 -1 B 1.6
  -1 1 B 1.7
   -1 -1 B 1.6
   ;
    proc glm;
class Time Power Brand;
model Volume=Time|Power|Brand/solution;
run;
```

The GLM Procedure

Class Level Information

Class	Levels	Values
Time	2	-1 1
Power	2	-1 1
Brand	2	A B

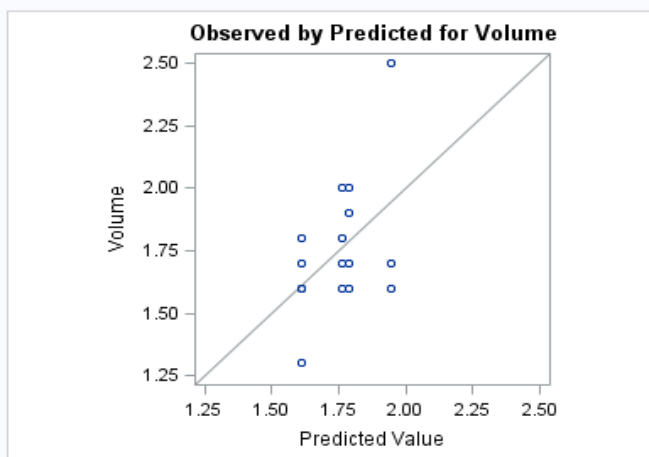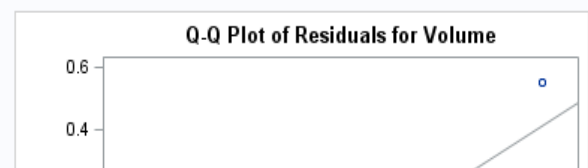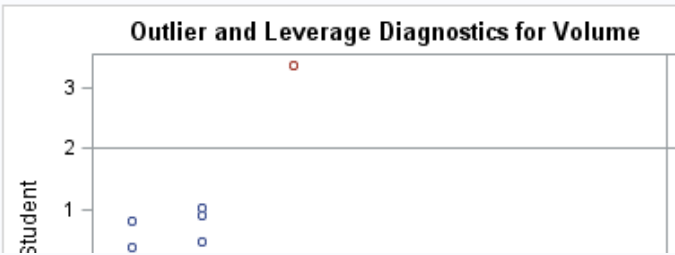| Number of Observations Read	16
Number of Observations Used	16

The GLM Procedure

Dependent Variable: Volume

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	0.91270833	0.13038690	8.23	0.0040
Error	8	0.12666667	0.01583333		
Corrected Total	15	1.03937500			

R-Square	Coeff Var	Root MSE	Volume Mean
0.878132	7.164730	0.125831	1.756250

Popcorn Experiment

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Time	1	0.09334325	0.09334325	5.90	0.0413
Power	1	0.13018497	0.13018497	8.22	0.0209
Time*Power	1	0.00168011	0.00168011	0.11	0.7530
Brand	1	0.49771505	0.49771505	31.43	0.0005
Time*Brand	1	0.05420562	0.05420562	3.42	0.1014
Power*Brand	1	0.06676980	0.06676980	4.22	0.0741
Time*Power*Brand	1	0.06880952	0.06880952	4.35	0.0706

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Time	1	0.11523810	0.11523810	7.28	0.0272
Power	1	0.24380952	0.24380952	15.40	0.0044
Time*Power	1	0.02880952	0.02880952	1.82	0.2143
Brand	1	0.57166667	0.57166667	36.11	0.0003
Time*Brand	1	0.06095238	0.06095238	3.85	0.0854
Power*Brand	1	0.09523810	0.09523810	6.02	0.0398
Time*Power*Brand	1	0.06880952	0.06880952	4.35	0.0706

Residuals by Predicted for Volume

Outlier and Leverage Diagnostics for Volume

Q-Q Plot of Residuals for Volume

Observed by Predicted for Volume

Distribution of Residuals for Volume
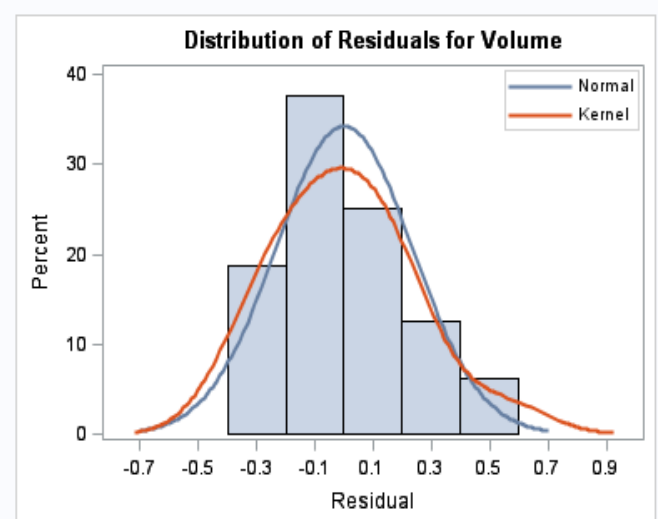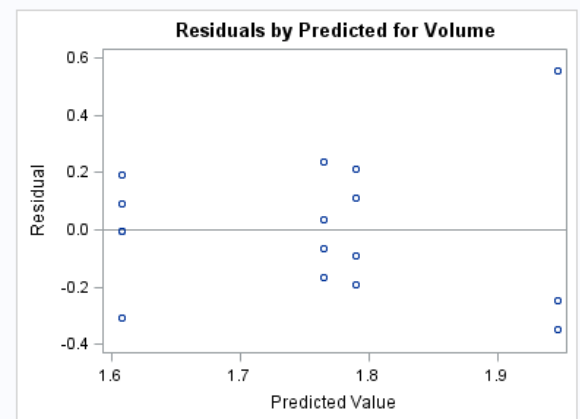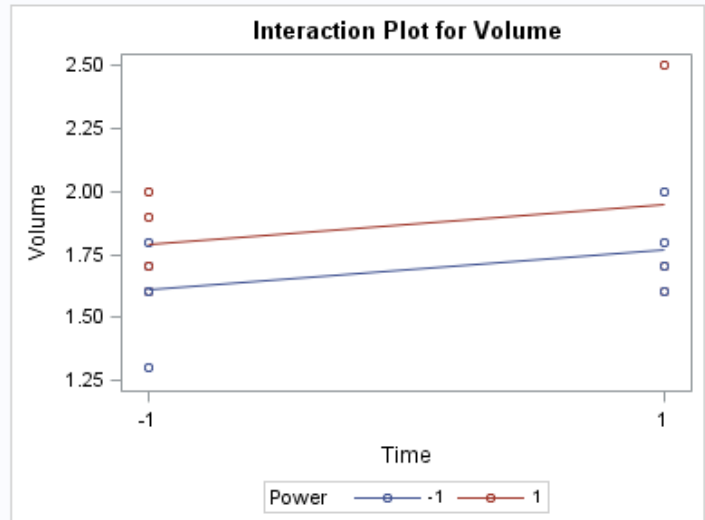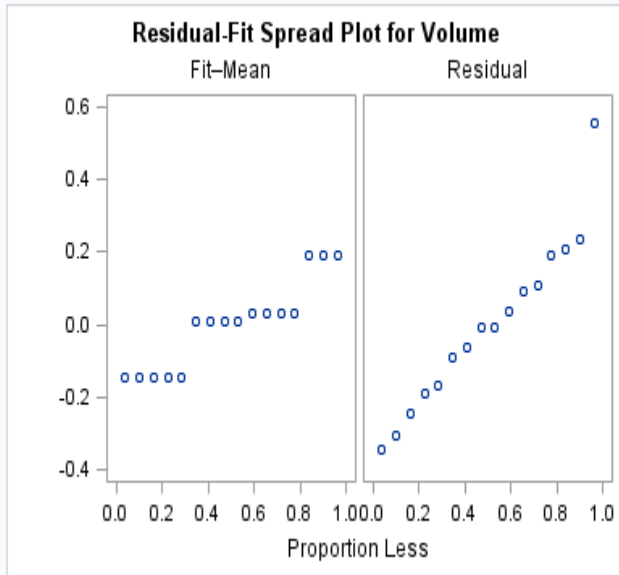
Based on the ANOVA table above, all the factors appear to be significant on the volume of popped kernel. The residuals showed the behavior of equal variances and normal distribution with one or two outliers that could still be analyzed. Our interaction graph shows that there is no interaction between the factors or factor combination, though the factors are significant.

Even though, there was no interaction between the factors, we can observe from our interaction plot that there were more popped kernel and one outlier at high power and long time than at low power and short time. Orville Redenbacher had a somewhat uniform Popped kernel and when left out of the bag package for some few minutes, had the same shape and texture whereas the Pop weaver lose its popped shape and texture.

Since our design was a 2^k factorial design with 3 factors, its model is written as:

$$Y_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + e_{ijkl}$$

Where $i = 1, ..., a, \, j = 1, ..., b, k = 1, ..., c, l = 1, ..., n$.

Conclusion

Our question for this experiment was trying to discover which brand of the selected popcorn popped the most kernels. In our experiment, we noticed that Orville Redenbacher popped the most amount of popcorn while Pop weaver popped the least. This explains the reason why Orville Redenbacher is well known and most popular brand of popcorn in our time. This is result is important because you can get the value of your money spend on popcorn. Other that could be done are going further to compare brand taste.

References

Lawson, J.(2010). Design and Analysis of Experiment with SAS. Chapman & Hall/CRC,Boca Raton,FL

Mohala Kaliebe, The study of how cooking Popcorn in a microwave Affects How many Kernels pop and Why, Cary Academy, 2012.