701 Project Report

1. Introduction

Objective:
To understand the relationship between the effect of Method used and the Type of Egg on the boiling Time.

Goal: To minimize the boiling time based on the Method used and the Type of the Egg.

The Factor Information is as follows,

Factor	Type	Levels	Values
Operator	Fixed	2	1, 2
Eggs	Fixed	2	Brown, White
Method	Fixed	2	Coil, Microwave

Response variable : Time taken by the Egg to boil (in mins).

2. Experimental Design

The Design used for the study is Randomised Complete Block Design (RCBD) with 2 factors and one Block each at 2 levels.
The other design we took under consideration was 2^2 Factorial Experimental with One block.

Explain RCBD:

Experimental Layout:

	Operator1		Operator2	
		Eggs		
Method	White	Brown	White	Brown
Coil	15	17	12	21
Microwave	6	8.5	5	7.5
Coil	15	20	16	20
Microwave	6.5	8	5.25	7
Coil	14	19	15	21
Microwave	6	7.5	5.5	7.5

3. Data Collection

The Data was Collected by two Operators with same skillset and understanding of hard boiling eggs required to note the Boiling Time . In this way, we could reduce bias due to Operator. However, there exists inevitable errors that account for measurement errors, noise etc.

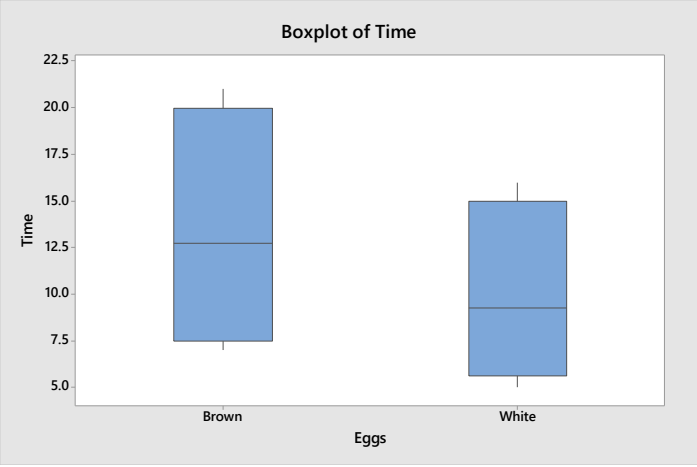
Each type of Egg was randomly assigned to each Method under consideration by each Operator.

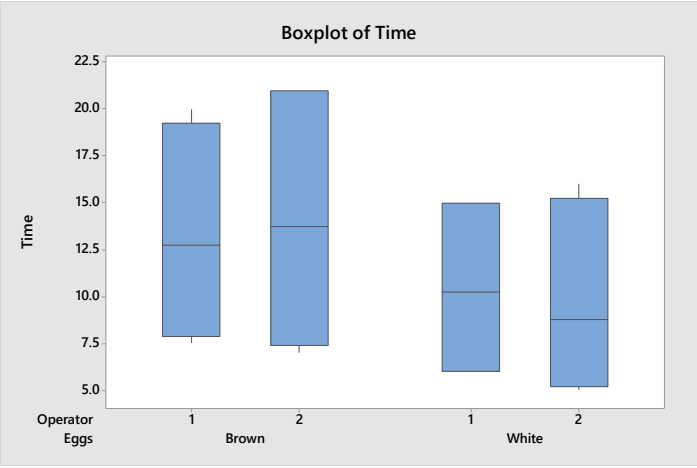
This Experiment was replicated 3 times.

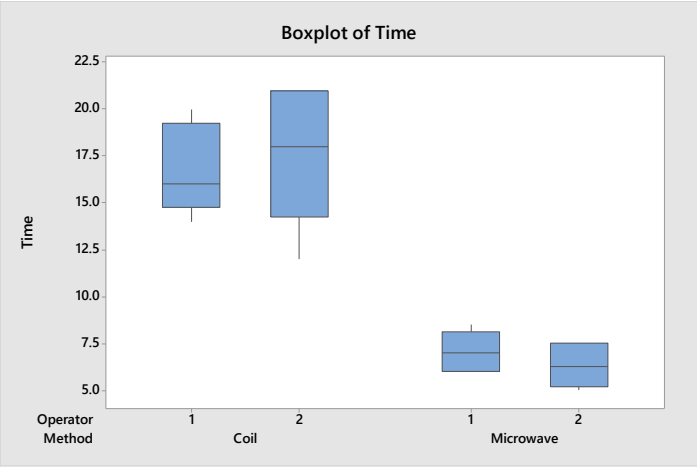
After each Experiment, the Coil and the Microwave were left to cool down. The next experiment was started only after they were back to the normal room temperature (Initial Condition) inorder to avoid carry-over effect.

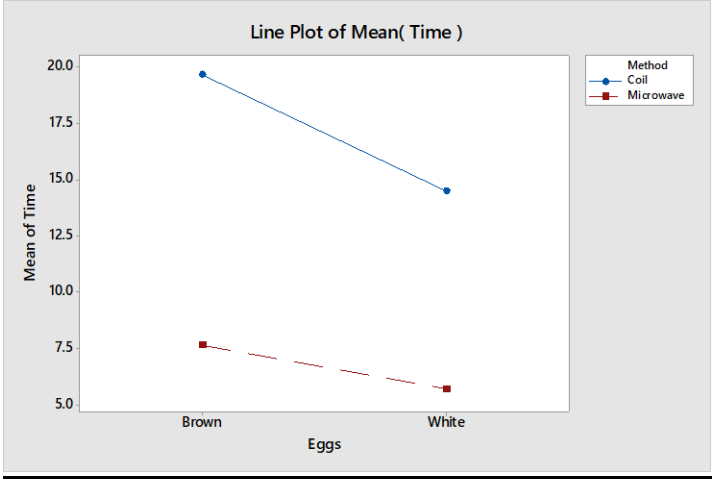
4. Data Analysis

Preliminary Analysis:


Boxplot of Time
Time
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Brown
White
Eggs


Boxplot of Time
Time
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Operator
Eggs
1
2
1
2
Brown
White


Boxplot of Time
Time
22.5
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Operator
Method
1
2
1
2
Coil
Microwave

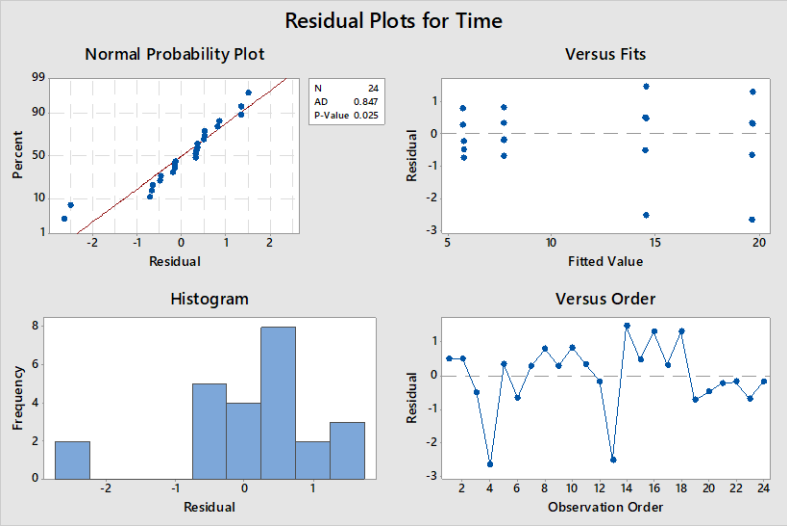


Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Operator	1	0.003	0.003	0.00	0.964
Eggs	1	76.148	76.148	61.01	0.000
Method	1	648.440	648.440	519.49	0.000
Eggs*Method	1	15.440	15.440	12.37	0.002
Error	19	23.716	1.248		
Lack-of-Fit	3	8.091	2.697	2.76	0.076
Pure Error	16	15.625	0.977		
Total	23	763.747			

From the Anova table, we see that the Operator is insignificant. All the other factors are significant.

Model Adequacy:



We see that the Normality Assumption appears to be violated.

Performing Log transformation on the data and conducting the analysis again,

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Operator	1	0.01126	0.01126	1.53	0.232
Eggs	1	0.54597	0.54597	73.98	0.000
Method	1	5.26501	5.26501	713.41	0.000
Eggs*Method	1	0.00013	0.00013	0.02	0.897
Error	19	0.14022	0.00738		
Lack-of-Fit	3	0.05626	0.01875	3.57	0.038
Pure Error	16	0.08396	0.00525		
Total	23	5.96258			

Now we see that the Interaction between Eggs and Method is insignificant.

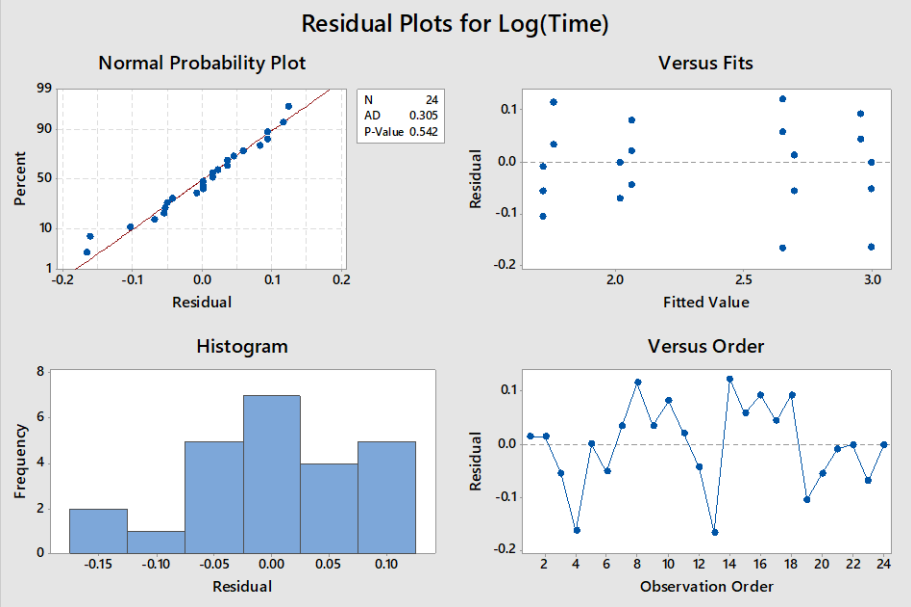
Thus, Reducing the model, we get,

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Operator	1	0.01126	0.01126	1.60	0.220
Eggs	1	0.54597	0.54597	77.80	0.000
Method	1	5.26501	5.26501	750.28	0.000
Error	20	0.14035	0.00702		
Lack-of-Fit	4	0.05639	0.01410	2.69	0.069
Pure Error	16	0.08396	0.00525		
Total	23	5.96258			

Here, we also see that the lack of fit is insignificant.

Checking for Model Adequacy,



Now we see that The normality assumption is satisfied.

Tests for Constant Variance:

Tests for Method

Method	Test Statistic	P-Value
Multiple comparisons	0.03	0.860
Levene	0.02	0.897

Tests For Eggs

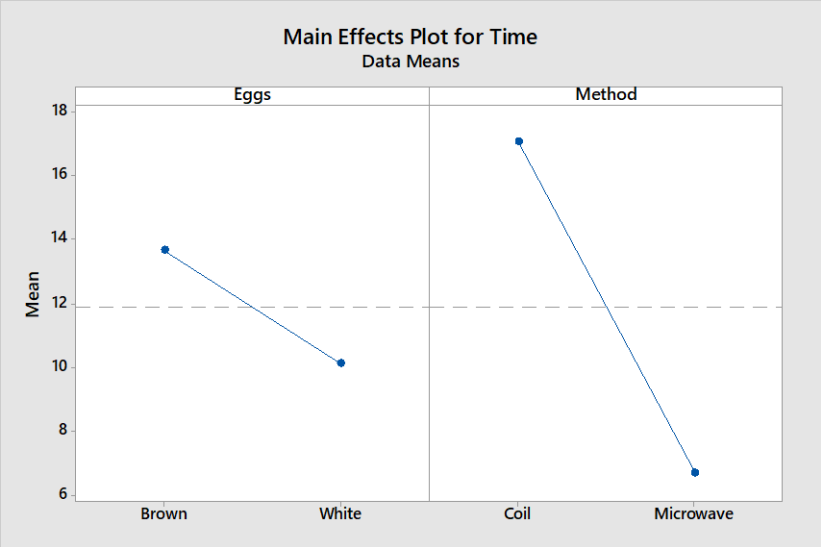
Method	Test Statistic	P-Value
Multiple comparisons	0.00	0.991
Levene	0.02	0.898

Tests for Operators

Method	Test Statistic	P-Value
Multiple comparisons	1.19	0.276
Levene	1.16	0.293

From the above plots and the tests we can say that, the model is adequate.

5. Conclusion and Recommendation



With our Objective of Minimising the Boiling time, We recommend to set the factors at the following levels;

Eggs: White

Method: Microwave