

LAB 11: Latin Square Design (LSD)

The effects of five different ingredients (A, B, C, D, E) on the reaction time of a chemical process is being studied. Each batch of new material is only large enough to permit five runs to be made. Furthermore, each run requires approximately 1.5 hours, so only five run can be made in one day. The experimenter decides to run the experiment as 5X5 LSD so that day and batch effects may be systematically controlled. Data follow.

Batch	Day				
	1	2	3	4	5
1	A = 8	B = 7	D = 1	C = 7	E = 3
2	C = 11	E = 2	A = 7	D = 3	B = 8
3	B = 4	A = 9	C = 10	E = 1	D = 5
4	D = 6	C = 8	E = 6	B = 6	A = 10
5	E = 4	D = 2	B = 3	A = 8	C = 8

Analyze the data from this experiment and draw conclusions.

Solution

Factor Information

Factor	Type	Levels Values
Ingredients	Fixed	5 A, B, C, D, E
Batch	Fixed	5 1, 2, 3, 4, 5
Day	Fixed	5 1, 2, 3, 4, 5

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Ingredients	4	139.85	34.962	10.57	0.001
Batch	4	13.28	3.320	1.00	0.443
Day	4	12.57	3.143	0.95	0.469
Error	12	39.68	3.307		
Total	24	206.64			

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
1.81844	80.80%	61.59%	15.97%

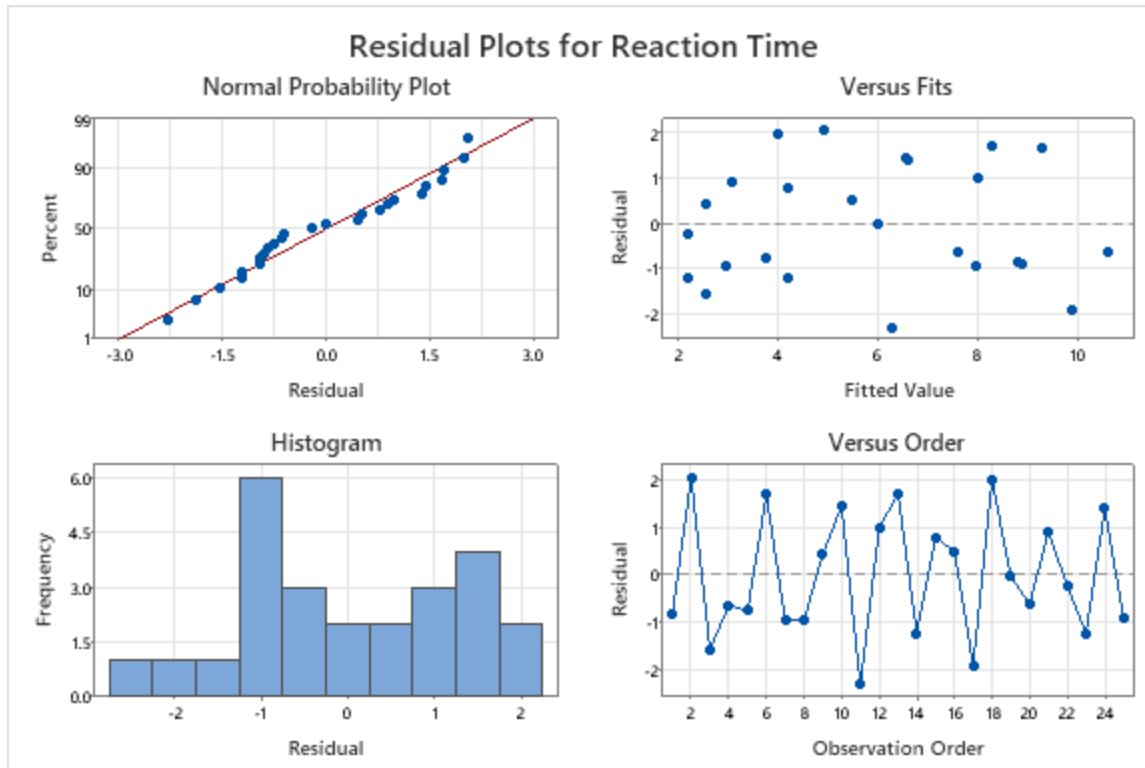
Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	5.896	0.367	16.06	0.000	
Ingredients					

A	2.504	0.729	3.43	0.005 1.61
B	-0.296	0.729	-0.41	0.692 1.61
C	2.985	0.755	3.95	0.002 1.72
D	-2.496	0.729	-3.42	0.005 1.61
Batch				
1	-0.358	0.711	-0.50	0.624 1.68
2	0.046	0.835	0.06	0.957 1.89
3	-0.096	0.729	-0.13	0.897 1.61
4	1.304	0.729	1.79	0.099 1.61
Day				
1	0.785	0.755	1.04	0.319 1.72
2	-0.296	0.729	-0.41	0.692 1.61
3	-0.496	0.729	-0.68	0.509 1.61
4	-0.896	0.729	-1.23	0.243 1.61

Regression Equation

$$\begin{aligned}
 \text{Reaction Time} = & 5.896 + 2.504 \text{ Ingredients_A} - 0.296 \text{ Ingredients_B} \\
 & + 2.985 \text{ Ingredients_C} - 2.496 \text{ Ingredients_D} \\
 & - 2.696 \text{ Ingredients_E} - 0.358 \text{ Batch_1} + 0.046 \text{ Batch_2} \\
 & - 0.096 \text{ Batch_3} + 1.304 \text{ Batch_4} - 0.896 \text{ Batch_5} \\
 & + 0.785 \text{ Day_1} - 0.296 \text{ Day_2} - 0.496 \text{ Day_3} - 0.896 \text{ Day_4} \\
 & + 0.904 \text{ Day_5}
 \end{aligned}$$



Conclusion:

1. ANOVA tables shows that the ingredients is significant factor ($p\text{-value} = 0.001$) for reaction time. The row blocking factor Batches is insignificant factor (0.443) and column blocking factor Day is also insignificant factor ($p\text{-value} = 0.469$). It means that Completely Randomized Design can be used for the experiment as blocking factors (nuisance variables) are insignificant
2. The reliability of linear model fitted for LSD is not very high (61.59 %). So, linear model do not sufficient predict reaction time knowing particular ingredients, batch and day.
3. Graphs shows the following:
 - (a) distribution of error is almost normal
 - (b) Homogeneity of variance required for the linear model is maintained
 - (c) Errors are not related as errors shows random patter (4 th graph)

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SN	LAB REPORT	DATE	REMARKS
1	Simple Random Sampling	2023-06-02	
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