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COOKING OIL ABSORPTION AND EXPERIMENTAL DESIGN

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ABSTRACT

Most of the people especially the young like to eat fast foods while it is considered their main meal in a day. Some of the disadvantages beyond consuming the unhealthy fast foods are the danger in cholesterol level and the fat gained. The selection of unhealthy oil product for cooking is one of the reasons that may harm the human health. The goal of almost all companies manufacture cooking oil is to produce health pure oil and the oil absorption is minimal while cooking. The study analyzed different cooking oil products and checked the percentage of oil absorption while cooking. The experiment recommends the use of cooking oil among others for better health.

KEYWORDS: cooking oil; potato; experimental design.

INTRODUCTION

The major impact on blood cholesterol level is the combination of fats and carbohydrates in the consumed food. High cholesterol level is a factor for heart disease, stroke, and peripheral artery disease. The use of unneeded amount of oil in the food cooking maybe danger the health and it is a root of higher cholesterol level.

Experimental design is a scientific method that is used to design experiments to test hypotheses by controlling factors to better forecasting for a result based on dependent and independent variables. This study considered different kind of cooking oil products and potatoes to be experimentally designed and analyzed. The goal of this study is to minimize the percentage of oil absorption while cooking. The approach used is the design of experiment that recommends one kind of oil and potatoes that satisfied the given objective.

The remainder of this paper is organized as follows. The next sections presents the experimental design and cooking oil, the problem definition, the approached used, the results and analysis, and the conclusion and recommendations.

EXPERIMENTAL DESIGN AND COOKING OIL

The bad food habit danger human life specially getting used for junk foods that causes many diseases. In 1960s, Finland had the highest cardiovascular mortality in the world. The classical cardiovascular risk factors were all common, but serum cholesterol level was very high because of the high consumption of saturated fats. The governments of Finland considered a preventive program to the whole population to reduce serum cholesterol levels by reducing the consumption of saturated fats and increasing the consumption of polyunsaturated fats. Yet, the saturated fats were reduced from 20% of energy consumption to 12% in 2007 but increased from 2007 to 2012 to 14%. It is found that the serum cholesterol reduction is feasible on the population level but requires active work and large-scale cooperation between all the meaningful sectors in the society (Vartiainen, Laatikainen, Tapanainen, & Puska, 2016).

Design of experiment is a procedure used to analyze number of controllable factors in order to find the responses of interest. It also studies the effects of independent and dependent factors. The techniques usually used for experimental design are full factorial design, fractional factorial design, Taguchi design, Plackett–Burman design, and central composite design and / or Box–Behnken design.

For instance the bioengineering application is investigated by experimental design method for optimization with respect to number of factors. The experimental design studied several factors linked to the bioengineering process that affect and govern the area of scientific interest and obtain the responses for proper guidance of the situation (Gündoğdu, Deniz, Çalışkan, Şahin, & Azbar, 2016).

Another study consider using Taguchi method for experimental design. The optimization of biological decolonization of artificial dye solution containing Malachite Green was considered. The study also optimized the experimental parameters and selected the finest situation by determination effective factors. It determined the most effective parameter in comparison with others ("Biodegradation of dye solution containing Malachite Green: Optimization of effective parameters using Taguchi method," n.d.).

Therefore, the experimental design that useful for a planned study to meet specified objectives is suggested. The plan is to study the effectiveness of factors that may danger human health from eating junk foods or even cooking at home with poor oil and recommend the way to reduce the danger.

A study shows that the sunflower oil is the normally used cooking oil in Indian market. Although many claims reflected regarding its health benefits, and number of studies disproves this claim. Nevertheless, a study considered to investigate the health parameters between sunflower oil users and other cooking oil users. It is found that sunflower oil users have a significant increase in their Body mass index (BMI) and ALT levels when compared with that of other oil users (N, 2016).

THE PROBLEM DEFINITION

The Experiment is concerned with the three types of fresh potatoes. The potatoes are uniform in size and shape. Their percentage of moisture is about %79.281 (this is the standard mean for potatoes as confirmed by QC in Savola Co.) The weight of used cooking oil (frying oils) before and after each process is measured. The data collected from the frying process considered for study (ΔW = W before – W after). The duration time for the process is 5 minutes with temperature 130 °C for the cooking oil, and 0.5 liter of the cooking oil per 100 g of the fresh potato. Where the symbols

1. W before : The weight of oil before the frying process.
2. W after : The weight of oil after the frying process.
3. ΔW : Difference between weight before and after.

The oil used is changed for each replicate, and 10 min wait time to make sure that the temperature of the oil is the same to all replicates. The tools used for the frying process in the home kitchen are pot, oil filter, cooking spoon, knife, filter spoon, cooking oil, cooker, kitchen tissue, cutting base, cutting device to uniform thickness, and cutting tool to uniform shape.

The objective of this study is to minimize the percentage of the absorbed oil in the fried potatoes. The factors and levels are divided into three categories.

1) Factors for the potato

1. The place of its harvest (Pakistani, Egyptian, Saudi –Ha'il) (Factor A).
2. Production date of the Potato (all are fresh).

3. Size of potato (uniformity in shape and size).
4. The percentage of moisture in the potato (the moisture of potatoes is %79.281 and is assumed constant).

2) Factors for the cooking oil

1. Kind of the oils (frying oil for cooking)
2. Brand of oils (Alarabi, Hayat, and Alnakhel) with different mixture for each (Factor B).
3. The oil mixture (serial number for each is provided as shown in Table 1).

3) Factors for the frying process

1. Time of the frying process (5 min).
2. Temperature of the cooking oil (130^{o} C).
3. Volume of the oil before the process (0.5 liter).
4. Weight of the potato before the process (100 g).

The response is to calculate the weight of the absorbed oil in the fried potatoes by measuring the weight of cooking oil before and after the frying process. Number of replication is 4 for treatment combinations. Number of treatments combinations is 9 (2 factors with 3 levels). Number of runs is 36 (number of treatment combinations times the number of replicates). The schematic diagram is shown in Figure 1. Also the design matrix is shown in Table 2.

THE METHODOLOGY

The experiment is passed into several stages

1. Washing and piling the fries then separate the potato in three plates according to the potato kind.
2. Cut the potato into chips slides with the same thickness.
3. Form the potato chips into same shape (leaf-shape).
4. Measure the weight of pot (500g), the weight of potatoes for each replicate (100g), the volume of cooking oil (2 cups = 0.5 L), the weight of the cooking oil (220 g).
5. Frying the potato in randomized order (the list designed in Minitab).
6. Filter the fried potato form the extra oil.
7. Measure the weight of the cooking oil after the process is done.
8. Calculate the ΔW (W before – W after) and record the results (in the list designed by Minitab).

RESULTS AND ANALYSIS

The factorial experiment is used to analyzes and estimate the effect of factors (Montgomery, 2008). The model and hypothesis are estimated as follow:

Means model: $Y_{ijk} = \mu_{ij} + \varepsilon_{ijk}$

Effects model: $Y_{ijk} = \mu + \tau_i + \beta_j + (\tau\beta)_{ij} + \varepsilon_{ij}$

The hypothesis:

$\Sigma \tau_i = 0$

$H_0: \tau_1 = \tau_2 = \ldots\ldots = \tau_a = 0$

H_1: at least one $\tau_i \neq 0$

$\Sigma \beta_j = 0$

$H_0: \beta_1 = \beta_2 = \ldots\ldots = \beta_b = 0$

H_1: at least one $\beta_j \neq 0$

$H_0: (\tau\beta)_{ij} = 0$ for i, j

H_1: at least one $(\tau\beta)_{ij} \neq 0$

Where i= 1, 2,….. , (a=3), j= 1, 2, ….. , (b=3), k= 1, 2,….. , (n=4)

The factorial design, linear model, analysis of variance, unusual observations, least squares means, and the weight of absorbed oil for the factorial design are shown Table 3, Table 4, Table 5, Table 6, Table 7, and Table 8 respectively.

The residuals in Table 8 are shown in the box on each cell. The 3rd column indicates the order of data collection. This is one of the DOE requirements.

The main effects plot for weight of absorbed oil and the interaction plot for weight of absorbed oil are shown in Figure 2, and Figure 3 respectively.

The Saudi brand of potato show better than other kinds while the oil called Alarabi show better as well among the other kinds in term of oil absorption. The brand of potato from Saudi shows the best among the other kinds. The following show that factor B (Brand of oil) has the most effect, then the interaction AB, and last is factor A (type of potato).

$(\text{Contrast A})^2 = SS_A * 4n = 26.056 * 16 = 416.896$

⇨ Contrast A = 20.418

⇨ Effect A = (1/(2n)) * (contrast a)

= 1/8 * 20.418 = 2.552

$(\text{Contrast B})^2 = SS_B * 4n = 347.389 * 16 = 5558.224$

⇨ Contrast B = 74.553

⇨ Effect B = (1/(2n)) * (contrast b)

= 1/8 * 74.553 = 9.319

$(\text{Contrast AB})^2 = SS_{AB} * 4n = 34.444 * 16 = 551.104$

⇨ Contrast AB = 23.475

⇨ Effect AB = (1/(2n)) * (Contrast AB)

= 1/8 * 23.475 = 2.934

The following analysis shows the hypothesis testing.

$\tau_i = F_{ά, (a - 1), ab(n - 1)}$

$\beta_i = F_{ά, (a - 1), ab(n - 1)}$

$(\tau\beta)_{ij} = F_{ά, (a - 1), ab(n - 1)}$

Assume that ά = 0.05

a= 3, b=3, n=4

$\tau_i = F_{0.05, 2, 27} = 3.35$

$\beta_i = F_{0.05, 2, 27} = 3.35$

$(\tau\beta)_{ij} = F_{0.05, 2, 27} = 3.35$

T_i: $F_0 > F_ά$ reject H_0 => 1.81 < 3.35

=> fail to reject H_0 , so Factor A is not significant.

=> $\tau_1 = \tau_2 = \ldots\ldots = \tau_a = 0$

β_i: $F_0 > F_ά$ reject H_0 => 24.17 > 3.35

=> reject H_0, so Factor B is significant.

=> at least one $\beta_j \neq 0$

$(\tau\beta)_{ij}$: $F_0 > F_ά$ reject H_0=> 1.20 < 3.35

=> fail to reject H_0 , so the interaction AB is not significant.

=> $(\tau\beta)_{ij} = 0$ for i, j

The Model below is used for Adequacy Checking:

- Model : $Y_{ij} = \mu + \tau_i + \varepsilon_{ij}$
- Residuals : $e_{ij} = Y_{ij} - \hat{Y}_{ij}$

ANOVA assumptions are studied via normality assumption and constant variance assumption. The normal plot of residuals for weight absorbed oil, residuals vs. fits for weight absorbed oil, residuals from weight absorbed oil vs. weight absorbed oil, residuals vs. order for weight absorbed oil, and residual histogram for weight absorbed oil are shown in Figure 4, Figure 5, Figure 6, Figure 7, and Figure 8 respectively.

The normality assumption is satisfied as shown in Figure 4. However, Figure 5 shows that the variance is not constant.

Table 1: The oil mixture information.

Oil Brand Name	Company	Serial Number
Al-Arabi	Savola	6281011131820
Nakheel	Savola	6281011132193
Hayat	Emirates Refining Company	6291003052217

Table 2: The design matrix.

Factors		Treatment Combination	Replicate				Total
A	B		I	II	III	IV	
+	+						
0	+						
-	+						
+	0						
0	0						
-	0						
+	-						
0	-						
-	-						

A: The Place of potatoes' harvest.

+: from Saudi. **0:** from Egyptian. **-:** from Pakistani.

B: The Brand of oil.

+: Alnakhel. **0:** Hayat. **-:** Alarabi.

Table 3: The general factorial design.

Factors: 2	Factor Levels: 3, 3
Runs: 36	Replicates: 4

Table 4: General linear model - weight of absorbed versus type of potato, and brand of oil.

Factors	Type	Levels	Values		
			Low	Mid	High
Type of potato	fixed	3	Saudi	Egyptian	Pakistani
Brand of oil	fixed	3	Alarabi	Nakhel	Hayat

Table 5: Analysis of variance for weight absorbed oil, and using adjusted SS for tests.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Type of potato	2	26.056	26.056	13.028	1.81	0.182
Brand of oil	2	347.389	347.389	173.694	24.17	0
Potato * Oil	4	34.444	34.444	8.611	1.2	0.334
Error	27	194	194	7.185		
Total	35	601.889				

Table 6: Unusual observations for weight absorbed oil.

Observation	Weight	Fit	SE Fit	Residual	St Residual
1	12	7	1.3403	5	2.15R
3	7	12.5	1.3403	-5.5	-2.37R
6	19	12.5	1.3403	6.5	2.80R

R denotes an observation with a large standardized residual.

Table 7: Least squares means for weight absorbed oil.

Type of Potato	Mean	SE Mean
Saudi	7.917	0.7738
Egyptian	10	0.7738
Pakistani	8.917	0.7738

Brand of Oil	Mean	SE Mean
Alarabi	4.583	0.7738
Nakhel	11.583	0.7738
Hayat	10.667	0.7738

Potato * Oil	Mean	SE Mean
Saudi * Alarabi	3.75	1.3403
Saudi * Nakhel	10.75	1.3403
Saudi * Hayat	9.25	1.3403
Egyptian * Alarabi	7	1.3403
Egyptian * Nakhel	12.5	1.3403
Egyptian * Hayat	10.5	1.3403
Pakistani * Alarabi	3	1.3403
Pakistani * Nakhel	11.5	1.3403
Pakistani * Hayat	12.25	1.3403

Table 8: The weight of absorbed oil for the factorial design.

Order	StdOrder	RunOrder	Blocks	Type of Potatoes	Brand of Oil	Weight of Oil Before Process	Weight of Oil After Process	Weight of Absorbed Oil	Residual
1	13	1	1	Egyptian	Alarabi	220	208	12	5
2	9	2	1	Pakistani	Hayat	220	211	9	-3.25
3	14	3	1	Egyptian	Nakheel	220	213	7	-5.5
4	35	4	1	Pakistani	Nakheel	220	211	9	-2.5
5	27	5	1	Pakistani	Hayat	220	205	15	2.75
6	32	6	1	Egyptian	Nakheel	220	201	19	6.5
7	17	7	1	Pakistani	Nakheel	220	209	11	-0.5
8	28	8	1	Saudi	Alarabi	220	215	5	1.25
9	7	9	1	Pakistani	Alarabi	220	217	3	0
10	6	10	1	Egyptian	Hayat	220	210	10	-0.5
11	30	11	1	Saudi	Hayat	220	212	8	-1.25
12	11	12	1	Saudi	Nakheel	220	205	15	4.25
13	29	13	1	Saudi	Nakheel	220	212	8	-2.75
14	15	14	1	Egyptian	Hayat	220	211	9	-1.5
15	19	15	1	Saudi	Alarabi	220	217	3	-0.75
16	18	16	1	Pakistani	Hayat	220	206	14	1.75
17	3	17	1	Saudi	Hayat	220	211	9	-0.25
18	12	18	1	Saudi	Hayat	220	209	11	1.75
19	10	19	1	Saudi	Alarabi	220	216	4	0.25
20	24	20	1	Egyptian	Hayat	220	209	11	0.5
21	16	21	1	Pakistani	Alarabi	220	218	2	-1
22	23	22	1	Egyptian	Nakheel	220	206	14	1.5
23	33	23	1	Egyptian	Hayat	220	208	12	1.5
24	1	24	1	Saudi	Alarabi	220	217	3	-0.75
25	31	25	1	Egyptian	Alarabi	220	215	5	-2
26	21	26	1	Saudi	Hayat	220	211	9	-0.25
27	25	27	1	Pakistani	Alarabi	220	217	3	0
28	34	28	1	Pakistani	Alarabi	220	216	4	1
29	4	29	1	Egyptian	Alarabi	220	214	6	-1
30	36	30	1	Pakistani	Hayat	220	209	11	-1.25
31	2	31	1	Saudi	Nakheel	220	209	11	0.25
32	8	32	1	Pakistani	Nakheel	220	206	14	2.5
33	22	33	1	Egyptian	Alarabi	220	215	5	-2
34	5	34	1	Egyptian	Nakheel	220	210	10	-2.5
35	26	35	1	Pakistani	Nakheel	220	208	12	0.5
36	20	36	1	Saudi	Nakheel	220	211	9	-1.75

Figure 1: The schematic diagram.

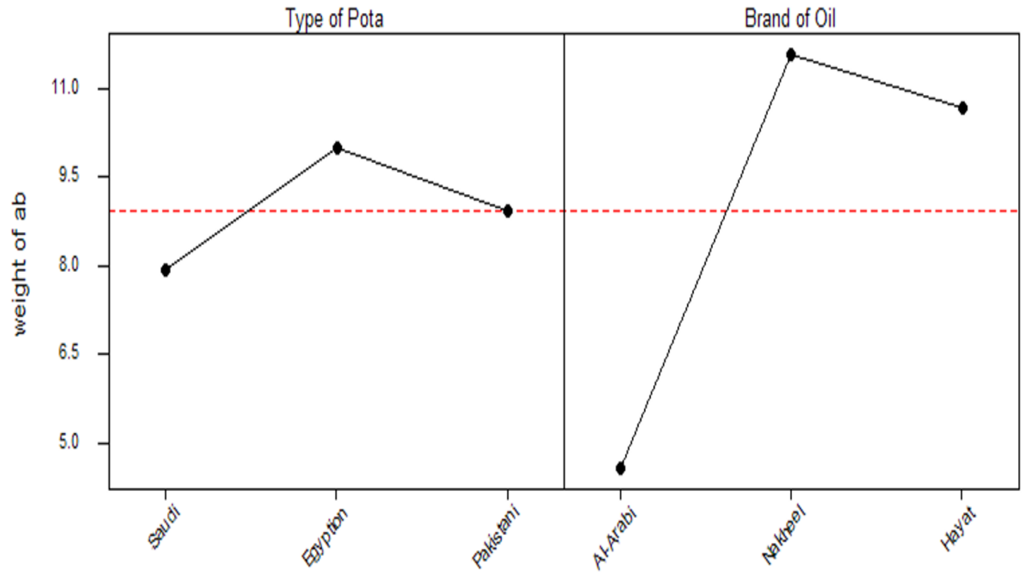

Figure 2: The main effects plot for weight of absorbed oil.

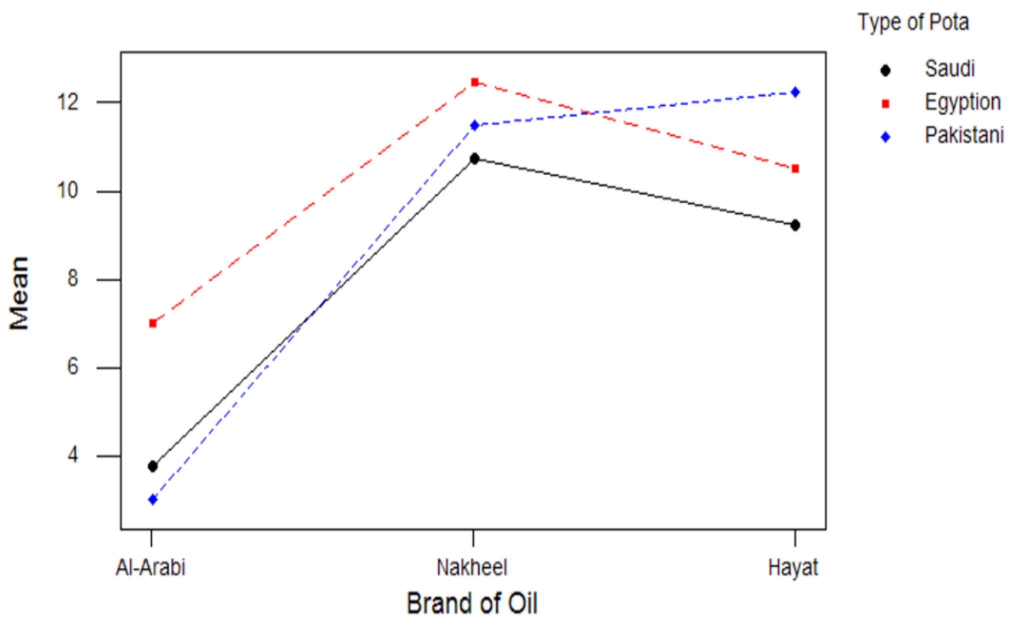

Figure 3: The interaction plot for weight of absorbed oil.

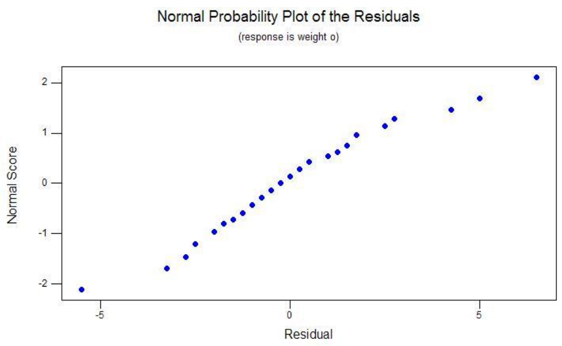

Figure 4: The normal plot of residuals for weight absorbed oil.

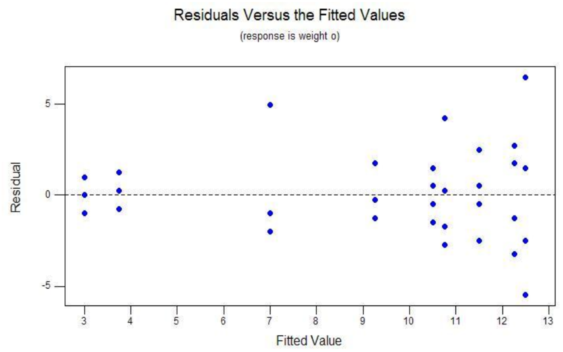

Figure 5: The residuals vs. fits for weight absorbed oil.

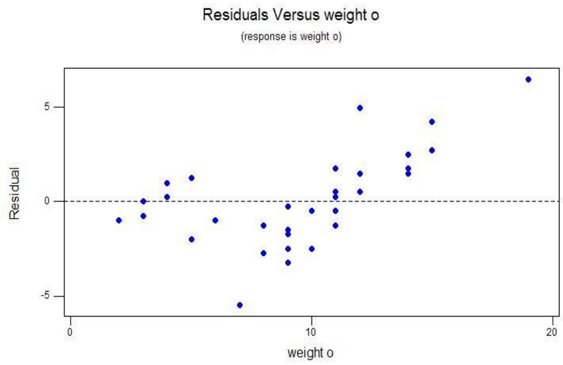

Figure 6: The residuals from weight absorbed oil vs. weight absorbed oil.

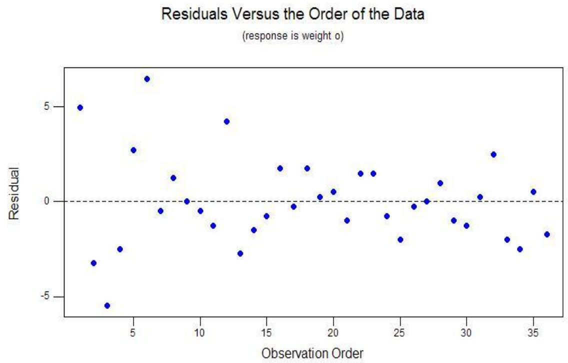

Figure 7: The residuals vs. order for weight absorbed oil.

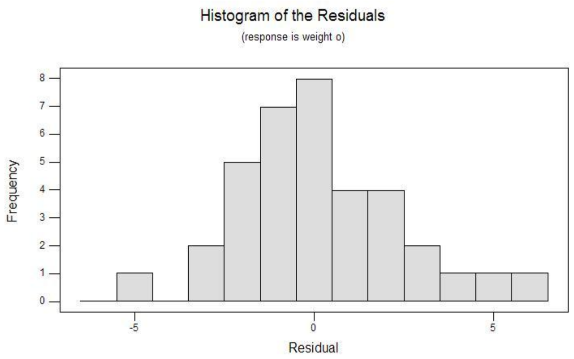

Figure 8: The residual histogram for weight absorbed oil.

CONCLUSION AND RECOMMENDATIONS

The Main effect plot indicated the oil absorption is minimal of the cooking oil called "Alarabi" compared to the others. Moreover, the Saudi Potato proved minimal oil absorption compared to the other kinds of potatoes. The proper selection of foods at start is better than late for better health.

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