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Optimization of Factorial Design with the type of Plackett-Burman Design to Study the Effects of Organic Rice Production Process: Second Step Experiment

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ABSTRACT

This research conducted the second experiment is to evaluate the results of organic rice production by controlling two variables. To consist of the spindle of speed and clearance between the rubber and two levels. The test statistics will be used. Factorial design Choose the type of Plackett-Burman design. Both variables and experiment levels have the effect of organic rice production process at the level of significance. To study the interaction among the factors a 36 factorial experiment approach has been adopted using the two basic principles of experimental design, replication and randomization. The process model was formulated based on Analysis of variance (ANOVA) and regression of coefficient using Minitab Release 15.00. The results showed that both variables were p value is greater than alpha value (0.216 > 0.05). There are no significant differences. Shows that the SS and CL is significant to the effect of organic rice production process. So, the conclusion is accepting H_0.

Key words : Factorial design, Placket-Burman design, ANOVA, regression of coefficient, optimization, production process, organic rice

1. INTRODUCTION

The quality of peeled rice is depending on many factors such as rice strain, the rate of feeding, clearance between a rubber to rubber cylinder and paddy moisture content which usually are controlled not to be exceed 14% [1], [2]. In rice milling, the bran layers and germ removed during polishing are high in fiber, vitamins and minerals as well as protein. Their removal results in loss of nutrients, especially in substantial losses of B vitamins. Polishing rice reduces the thiamin content of rice by over 80%. Parboiled rice is therefore higher in B vitamins than raw milled rice [3].

The enhancement of rice supply is another advantage of brown rice relative to polished or white rice. Post-harvest researchers say that the milling recovery in brown rice is 10% higher than polished rice [4]. There is the other benefit of brown rice – economics the fuel savings in milling is 50-60% because the polishing and whitening steps are eliminated. It follows that the milling time is also shortened; labor is less; and the cost of equipment (if the mill is dedicated to brown rice) is much lower because the miller doesn't have to install polishers and whiteners [5].

Milling strips off the bran layer, leaving a core comprised of mostly carbohydrates [6]. In this bran layer resides nutrients of vital importance in the diet, making white rice a poor competitor in the nutrition game the following chart shows the nutritional differences between brown and white rice. Fiber is dramatically lower in white rice, as are the oils, most of the B vitamins and important minerals [7]. Brown rice (hulled rice) is composed of surface bran (6–7% by weight), endosperm (E90%) and embryo (2–3%), [8]. White rice is referred to as milled, polished or whitened rice when 8–10% of mass (mainly bran) has been removed from brown rice [7]. During milling, brown rice is subjected to abrasive or friction pressure to remove bran layers resulting in high, medium or low degrees of milling depending on the amount of bran removed [7]-[10]. Milling brings about considerable loss of nutrients and affects the edible properties of milled rice [7]-[10]. As most cereals, rice does not show a homogeneous structure from its outer (surface) to inner (central), [11]. As a consequence, information on the distribution of nutrients will greatly help in understanding the effect of milling and aid in improving sensory properties of rice while retaining its essential nutrients as much as possible [12].

Therefore, the purpose of this second research is to generate between clearance of rubber and spindle of speed using Design of Experiment (DOE) by factorial design with type of plackett-burman design in order to generate the suitable factors. And the parameters are significant at the confidence level Ninety five percent per percentage of broken rice.

2. EXPERIMENTAL DESIGN

2.1. Factorial Design of Experiments

Optimum conditions are decided by changing several factors at once and using different levels of these factors. Factorial designs are widely applied in the experiments that are taking into account several factors where it is necessary to study the interaction effect of factors on the response [13]. 2^k factorial design of experiments needs a smaller number of experiments for several factors; thus, materials and time used are slightly reduced [14],15]. When factorial design methods applied to experiments of a process, mathematical models are derived through obtained variance analysis tables. Experiments are chosen randomly to prevent partiality of researchers [16].

The factorial design with type of design Placket-Burman design describes which factor shows more impact and influences the variation of one factor on the other factors [17]. The two factors; spindle of speed (SS) and the rubber of clearance (CL), respectively were varied at two levels as given in (see Table 1) to investigate their effects on response.

Table 1: Factors and levels for organic rice production experiment

Parameter	Variable	Lower Limit	Upper Limit
Spindle of speed, SS	X_1 (RPM)	1,420	1,460
Rubber of clearance, CL	X_2 (mm.)	1.0	1.2

Table 2: Design matrix for DOE 2^k factorials

Run Order	Pt Type	Blocks	X_1	X_2	% Broken
1	1	1	1	-1	24.64
2	1	1	1	-1	24.70
3	1	1	-1 -	1	11.60
4	1	1	1	-1	24.70
5	1	1	-1	1	19.00
6	1	1	-1	-1	12.80
7	1	1	-1	1	11.90
8	1	1	1	1	29.80
9	1	1	1	-1	23.60
10	1	1	1	1	29.90
11	1	1	-1	1	20.00
12	1	1	-1	-1	11.60
13	1	1	1	1	29.60
14	1	1	-1	1	19.10
15	1	1	-1	-1	10.80
16	1	1	-1	-1	9.90
17	1	1	-1	1	10.10
18	1	1	1	-1	24.60
19	1	1	-1	-1	9.80
20	1	1	1	1	29.30
21	1	1	-1	-1	10.10
22	1	1	1	-1	20.60
23	1	1	-1	1	20.70
24	1	1	1	1	20.60
25	1	1	1	1	29.20
26	1	1	1	-1	21.10
27	1	1	-1	1	20.00
28	1	1	-1	-1	13.60
29	1	1	-1	1	20.60
30	1	1	-1	1	17.90
31	1	1	1	1	29.10
32	1	1	1	1	29.20

Table 2: (cont.) Design matrix for DOE 2k factorials

Run Order	Pt Type	Blocks	X1	X2	% Broken
33	1	1	1	-1	24.80
34	1	1	1	1	29.60
35	1	1	1	-1	24.70
36	1	1	-1	-1	9.80

The 2^k = 36 factorial with three replicated treatment combinations were performed. Note that 36 samples were made at the coded treatment combination (0, 0). The observed percentage of good rice ranged from 9.80 to 29.60 %. Table 2 presents the results for all 2^k = 36 runs, run order by response. Therefore, thirty- six observations were taken in all to employ factorial design type of Plackett - Burman design as shown in (see Table 2). Throughout the experiment it was assumed that: the factor is fixed; the design was completely randomized and the usual normality assumptions of the data were satisfied.

2.2 Statistical Methods and Software

The analysis and results of the experimental design were studied and interpreted by MINITAB RELEASE 19.00 (PA, USA licensed to Department of Industrial Engineering, Faculty of Engineering, Rajamangala University of Technology Lanna, Chiang Mai, Thailand) statistical software to estimate the response of the dependent variable. The response curves and contour plots are also generated. After production process of organic rice, the response was calculated and analyzed using regression coefficient analysis and analysis of variance (ANOVA).

2.3 Hypothesis

Definition of Statistical hypothesis

Statistical hypothesis that are evaluated by appropriate statistical techniques.

There are two hypotheses involved in hypothesis testing

- Null hypothesis H_0: $\mu_1 = \mu_2$ (there is not significantly different in mean the percentage of broken rice).
- Alternative hypothesis H_1: $\mu_1 \neq \mu_2$ (at least one different in mean the percentage of broken rice).

The level of significance (α) is a probability and, in fact, is a probability of rejecting a true null hypothesis.

The level of significance (α) are as follows:

If the p-value < α, then reject H_0 that means there are at least one level significantly different.

If the p-value ≥ α, then failed to reject H_0 that means no significantly different.

3. RESULTS AND DISCUSSION

3.1 Results

The DOE simulation was accomplished with four parameters: spindle of speed and rubber of clearance respectively. It was performed according (see Table 1 and 2) , and of main effects for the broken rice as shown in Figure 1. A model fitting was accomplished for the first 2^k factorial design with type of Plackett-Burman design (see Table 1). The independent (SS and CL) and the dependent variables were fitted to the second-order model equation and examined in terms of the goodness of fit. All the independent variables were kept within range while the responses were either maximized or minimized. The significant terms in different models were found by analysis of variance (ANOVA) for each response. Significance was judged by determining the probability level that the F-statistic calculated from the data is less than 5%. The model adequacies were checked by R^2, adjusted-R^2 (adj-R^2). The coefficient of determination, R^2, is defined as the ratio of the explained variation to the total variation according to its magnitude. The calculated value is greater than the value in the table and therefore accepts the results that are significantly different at the confidence level (p-value > α, 0.316 > 0.05), (SS x CL) for source model and two-way interactions. A good model should have a large R^2, adj-R^2. Response surface plots were generated with MINITAB Release 19.00. The results of the above experiments then conducted analysis of variances (ANOVA) to determine the influence of factors on the response (see Table 3).

Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment because the principles and theories are the same, the results are different. That is the percentage of good rice and the percentage of broken rice.

Table 3: Analysis of variance (95 % confidence)

Source	DF	Adj SS	Adj MS	F-value	P-value
Model	3	1527.6	509.18	70.42	0.000
Linear	2	1520.0	760.02	105.12	0.000
SS	1	1230.1	1230.1	170.14	0.000
CL	1	289.91	289.91	40.10	0.000
2-Way Interactions	1	7.51	7.51	1.04	0.316
SS*CL	1	7.51	7.51	1.04	0.316
Error	32	231.37	7.23		
Total	35	1758.9			

Model summary	S	R-sq	R-sq(adj)	R-sq (pred)
	2.6889	86.85%	85.61%	83.35%

3.2. Hypothesis Testing

An alternative decision rule using the p - value definition. The p-value is defined as the smallest value of α for which the null hypothesis can be rejected.

If the p-value is less than or equal to α, we reject the null hypothesis (p < α).

If the p-value is greater than α, we do not reject the null hypothesis (p ≥ α).

Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment.

3.3.1 Spindle of Speed Factor

For the percentage of broken rice, the value of p was 0.000. Thus, the conclusion is rejecting H0, which means there are significant differences between the levels in the p. The response is shows that the response significant effect on production process of organic rice.

3.3.2 Clearance Factor

For the percentage of broken rice, the value of p was 0.000. Thus, the conclusion is rejecting H0, which means there are significant differences between the levels in the p. The response is shows that the percentage of broken rice significant effect on production process of organic rice.

3.2.3 Spindle of Speed and Clearance (Two-Way Interaction)

For interaction with the spindle of speed and clearance the value of *p* was 0.316. So, the conclusion is accepting H_0, which means there are no significant differences between the levels spindle of speed and clearance. This suggests that the interaction with the spindle of speed and clearance effect on production process of organic rice. The differences of broken rice between level of each factor as shown in Figure 1 and mean of broken rice of each level shown in (see Table 3 and see Table 4).

While the remaining interaction the p ≥ α which means there is significant difference between the level of the spindle of speed and clearance interaction. This suggests that the spindle of speed, and clearance are significant effect of broken rice in production process of organic rice. Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment.

Figure 1 shows the cube plots of the two factors (X_1 and X_2) the percentage of broken rice. The effect of a factor is the change in the percentage of broken rice produced by the change in level of factor. This is frequently called a main effect as it refers to the primary factor of interest in the experiment [18]. It was concluded that the larger the vertical line is Figure 1, the larger the change in of good rice when it is changing from level −1 to level +1. Please note that the statistical significance of a factor is directly related to the length of the vertical line [19].

Table 4: Code coefficients 2^k design)

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		20.25	0.448	45.19	0.000	
SS	11.691	5.846	0.448	13.04	0.000	1.00
CL	5.676	2.838	0.448	6.33	0.000	1.00
SS*CL	-0.913	-0.457	0.448	-1.02	0.316	1.00

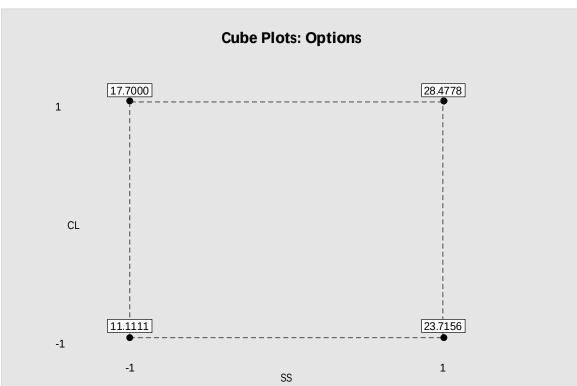

Figure 1: Cube plots: options of main effects for the broken rice.

Analysis of variance is a statistical method that partitions the total variation into its component parts each of which is associated with a different source of variation [17]. The interaction effects are easily estimated and tested by using the usual ANOVA. The ANOVA results of the response were shown in "Table 2". The sum of the squares used to estimate factors affect and Fisher's *F* ratios (defined as the ratio of mean square effect and the mean square error) and p values (defined as the level of significance leading to the rejection of the null hypothesis) were also represented.

The individual and interaction effects was given by the surface plot chart of the percentage of broken rice the effects between SS and CL in as shown in Figure 2.

Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment.

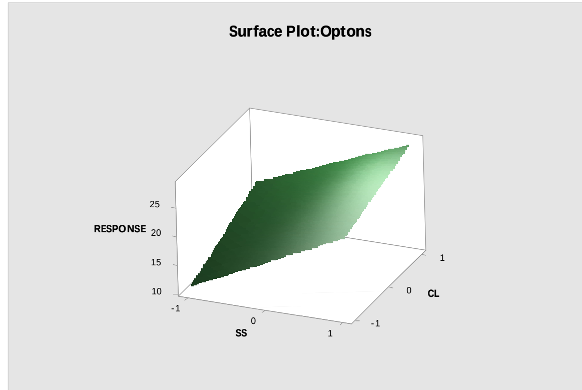

Figure 2: Surface plots: percentage of broken rice

4 CONCLUSIONS

A factorial experiment design type of Plackett-Burman design has been developed which can be used for the optimization of output organic rice of the production process of the organic rice. Such a model not only assists to estimate the magnitude and direction of the effects of change in factors but also predicts the effects of their mutual interactions. Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment.

The experimental results show that the spindle of speed and clearance factor did not have a significant effect on the response. The spindle of speed and clearance has a significant impact on the response. The optimal level of spindle of speed and clearance are 1,420 rpm and 1.00 millimeters respectively. Production process of organic rice at this level will meet the requirement of Community enterprises. The response with the two-level selected of organic rice can be modeled using the factorial design with type of Plackett-Burman design, as well as the response surface regression method. The value of R2 (97.18 %) and R2 adj (96.92 %) of the obtained models show that the models fit all the cases. Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment.

The significant effect of independent factors was analyzed using ANOVA, and the effect was also reported in the form of maim effects plots. The design of experiments provides efficient tools for the optimization of variable factors for general by factorial design type of Plackett-Burman design. Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of organic rice production process: first step experiment.

After the experiment, it was found that the difference between the first article and the second article was the Percentage of good rice and percentage of broken rice respectively. The article that one has the best good rice percentage is 90.280, as for this article, the percentage of broken rice is the best equal to 9.80.

The application of experimental design techniques using Factorial Design with a type of Plackett-Burman Design showed widespread confidence in the manufacturing industry and the ability to analyze and know the variables studied. Significant desired results. The experimental design can therefore be described with great statistical certainty as well as being able to expand results leading to actual use.

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