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The Factorial Design with the type of Plackett-Burman to Determine the Optimization in the Brown Rice Production Process

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ABSTRACT

This research aims to improve the paddy husking process by experimenting with Hom Nin rice. By designing a factorial experiment, placket-Berman type, to determine the optimum value in the husking process to obtain the lowest and best percentage of broken rice in the husking process. By controlling factors two variables are the spindle of speed, and the clearance of rubber for the two rubbers. The process model was formulated based on analysis of variance (ANOVA) and regression of coefficient. The results showed that both variables were *p* value is greater than alpha value (0.278 > 0.05). The percentage of broken rice was at 8.76 at the confidence level 95 percent significance between the two factors That are, the spindle of speed is equal to 1,420 rpm and the clearance rubber between the two rubbers are equal to 1 millimeters.

Key words: Analysis of variance (ANOVA), regression of coefficient, optimization, factorial design, Placket-Burman, brown rice, Hom Nin 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 with Hom Nin test.

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 brown 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	23.52
2	1	1	1	-1	23.61
3	1	1	-1 -	1	10.10
4	1	1	1	-1	23.58
5	1	1	-1	1	17.03
6	1	1	-1	-1	11.25
7	1	1	-1	1	12.10
8	1	1	1	1	27.50
9	1	1	1	-1	22.45
10	1	1	1	1	28.73
11	1	1	-1	1	19.15
12	1	1	-1	-1	10.55
13	1	1	1	1	27.95
14	1	1	-1	1	18.85
15	1	1	-1	-1	11.87
16	1	1	-1	-1	8.89
17	1	1	-1	1	9.97
18	1	1	1	-1	23.76
19	1	1	-1	-1	8.76
20	1	1	1	1	27.25
21	1	1	-1	-1	9.21
22	1	1	1	-1	19.50
23	1	1	-1	1	21.35
24	1	1	1	1	21.15

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

Run Order	Pt Type	Blocks	X1	X2	% Broken
25	1	1	1	1	28.21
26	1	1	1	-1	20.95
27	1	1	-1	1	19.68
28	1	1	-1	-1	12.79
29	1	1	-1	1	19.56
30	1	1	-1	1	16.56
31	1	1	1	1	28.22
32	1	1	1	1	28.35
33	1	1	1	-1	23.75
34	1	1	1	1	28.45
35	1	1	1	-1	23.66
36	1	1	-1	-1	8.78

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 broken rice ranged from 8.76 % to 28.73 %. 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 [20], [21].

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 brown rice, the response was calculated and analyzed using regression coefficient analysis and analysis of variance (ANOVA) [20], [21].

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 [20], [21].

3. RESULTS AND DISCUSSION

3.1 Results

The experimental design of the Berman packet method was controlled by two factors: The speed of rotation and the clearance between the two rubbers. The best results were obtained and the most suitable was the percentage of broken rice equal to 8.76 at which rpm is at 1420 RPM, and clearance between the two rubber is 1- millimeter. The level of 19 in (see Table 1 and 2) respectively.

From the analysis of variance, it was found that the adjusted decision coefficient is at 84.57 percent. A confidence level of 95 % found that the two factors interacted together: The spindle of speed, and the clearance of rubber between the two tires is *p* equal to 0.278 which is greater than the value of 0.05. shown in (see Table 3)

From this experimental design, it was found that the important variables involved in the experiment were relative humidity outside, workers, weather conditions, and the experimental unit but the working group has tried to consider such factors to be acceptable. It can be seen from the result that the percentage of broken rice was equal to 8.76 and five more experiments confirmed the results at the spindle of speed equal to 1420 RPM, with the clearance between the two-rubber equal to 1-millimeter values averaged between 8.67 to 8.81 respectively.

Table 3: Analysis of variance

Source	DF	Adj SS	Adj MS	F-value	P-value
Model	3	1476.8	489.21	69.53	0.000
Linear	2	1451.0	723.15	111.23	0.000
SS	1	1187.1	1146.3	168.26	0.000
CL	1	277.69	276.54	39.22	0.000
2-Way Interactions	1	6.62	6.62	6.62	0.278
SS*CL	1	6.62	6.62	6.62	0.278
Error	32	229.41	6.74		
Total	35	1621.6			
Model summary		S	R-sq	R-sq(adj)	R-sq (pred)
		2.5789	85.78%	84.57%	84.15%

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 ($p < \alpha$).

If the p-value is greater than α, we do not reject the null hypothesis ($p \geq \alpha$).

Consistent with the first article is optimization of Factorial Design with the type of Plackett-Burman design to study the effects of brown 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 H_0, 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 brow rice.

3.3.2 Clearance Factor

For the percentage of broken rice, the value of *p* was 0.000. Thus, the conclusion is rejecting H_0, 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 brown 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 0.278. 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 brown 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 $p \geq \alpha$ 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 brown rice. Consistent with the first article is optimization of factorial design with the type of Plackett-Burman design to study the effects of brown rice production process: first step experiment [20],[21].

Figure 1 shows the factorial plot versus mean response 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]. Please note that the statistical significance of a factor is directly related to the length of the vertical line [19].

3.3 Discussion

Applying experimental design principles by of Factorial Design with the type of Plackett-Burman design to assist in the paddy husking process to determine the minimum and optimal percentage of broken rice. In this research, two variables were studied: spindle of speed and the clearance of rubbers between the two rubbers. That was found that the optimal value was 8.76 percent. After obtaining the desired answer, the experiment was repeated five times. has an average of 8.67 to 8.81 percent respectively shows that the desired target value is significant in the confidence level of 95 percent.

Table 4: Code coefficients 2^k design

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		22.05	0.376	44.21	0.000	
SS	10.798	6.245	0.376	12.78	0.000	1.00
CL	4.787	3.324	0.376	5.16	0.000	1.00
SS*CL	-0.897	-0.379	0.376	-1.11	0.296	1.00

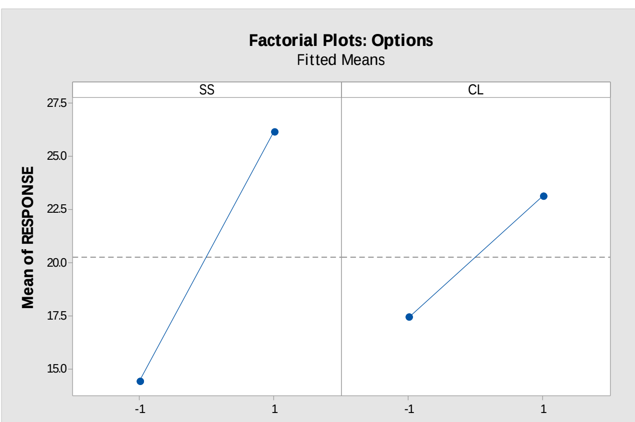

Figure 1: Cube plots: options of main effects for the broken rice

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 (see 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 contour plot of the percentage of response 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 brown rice production process: first step experiment and second step experiment respectively [20], [21].

Figure 2: Contour plot: options of response

4 CONCLUSIONS

Applying Factorial Design principles with the type of Pleckett- Burman to the brown rice production process, the researchers conducted a significant experiment at a confidence level of ninety-five percent. From the variance analysis at alpha 0.05, The two coefficients were co-reactive for the spindle of speed, and the clearance between the two rubbers at 0.278, and the adjusted decision coefficient was 84.57 %, and the percentage of broken rice is equal to 8.76, which is a very small value. It shows that the percentage of good rice is high. But there were some contributing factors during the trial, such as external relative humidity, labor, weather conditions and the equipment to be tested such co-factors need to be taken into account when experimenting. which cannot be controlled.

In this experiment, the control factors consisted of a spindle of speed and the clearance between the two rubbers. The most suitable value is the spindle of the speed, and the clearance between the two rubber is equal the percentage of broken rice is 8.76.

Where the adjusted decision coefficient is at 84.57% thus, the brown rice production process has a very little percentage of broken rice. But on the contrary, the percentage of rice is more good. It shows that the application of experimental design principles with the packet type factorial design method Berman had significant convictions.

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 91.24, as for this article, the percentage of broken rice is the best equal to 8.76.

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.

In this research, Hom Nin rice varieties were selected. from the same plantation control, the humidity of paddy between twelve to fourteen percent, and such paddy varieties must be clean and free from dust particles that are contaminated with paddy. Make the most suitable and affect rubber does not damage the rubber faster than scheduled.

Hom-nin rice is one of Thailand's varieties, fragrant, and highly nutritious. For this research, all were selected from the same source. The tested Hom Nin rice was very clean and free of any impurities in the paddy. In terms of shellers, they are effective for households, easy to move. There is a production control at every step, the result. Therefore, the percentage of broken rice is very low. Compared to the machines that are available in the general market. In this research, a better percentage 35 percent

According to [20], [21] both articles aimed to determine the optimal value of organic rice. The results of the two papers were not significantly different because they used the first and second-stage factorial designs with the type of Placket Berman experimental designs. This research section uses the same principles as the two articles mentioned. But different in the part of the rice varieties that were tested for efficiency. In this research, Hom Nin rice varieties were selected. It was found that the percentage of broken rice was the least at 8.76.

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