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EFFECTS OF SOAKING PROCESS AND ROTATING METHOD ON EDIBLE BIRD NEST CLEANING TIME AND CLEANLINESS

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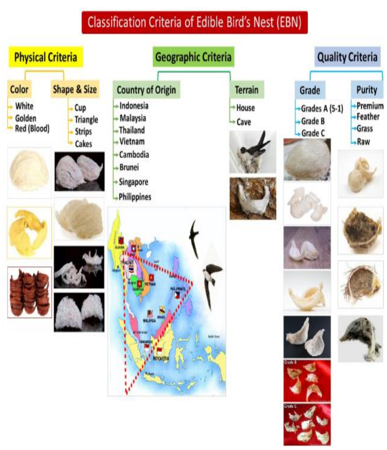
Graphical abstract



Abstract

The paper examines the effects of rotation and soaking processes on the cleaning time and cleanliness of edible bird nests (EBN). During breeding season, swift's species known as Aerodramus secrete salivary glands to build a nest that humans harvest. To be sold, the harvested EBN must be cleaned. The raw EBN cleaning process consists of four operations: soaking, cleaning, reshaping, and drying. Generally, harvested EBN is cleaned manually using tweezers. However, this procedure is time-consuming, as cleaning one EBN take about an hour. Therefore, several mechanical cleaning methods were required to clean raw EBN to improve cleaning time and cleanliness. This research aims to improve the two mechanical cleaning methods, rotating and soaking. The Taguchi Method is used to design and optimize the overall parameter setup. The selected optimized parameter set will be tested to determine the best parameter sets. For the current study, EBN wetting process has time settings of 12, 18, and 24 hours. The rotating method's time settings were 30, 45, and 60 seconds. The soaking time can be set to 2, 4, or 6 minutes. Each of these parameters is thoroughly tested to determine the best-optimized one. The experiment is then carried out by combining the two parameters chosen in a sequence to determine the cleanliness of the raw EBN. According to the experiments' results, the cleaning sequence contributes 63.75 percent cleanliness at a cleaning time of 5 minutes, which includes a soaking time of 4 minutes and a rotating method of 60 seconds.

Keywords: Rotating, soaking, edible bird nest, taguchi method, optimization

Abstrak

Kertas kerja mengkaji kesan proses putaran dan rendaman terhadap masa pembersihan dan kebersihan sarang burung yang boleh dimakan (EBN). Semasa musim pembiakan, spesies burung walit yang dikenali sebagai Aerodramus merembeskan kelenjar air liur untuk membina sarang yang dituai manusia. Untuk dijual, EBN yang dituai mesti dibersihkan. Proses pembersihan EBN mentah terdiri daripada empat operasi: merendam, membersih, membentuk semula dan mengeringkan. Kertas kerja ini memberi tumpuan kepada pembersihan EBN mentah. Secara umum, EBN yang dituai dirawat secara manual menggunakan pinset. Walau bagaimanapun, prosedur ini memakan masa, kerana pembersihan satu EBN boleh mengambil masa kira-kira sejam. Oleh itu, beberapa kaedah pembersihan mekanikal diperlukan untuk membersihkan EBN mentah untuk meningkatkan masa dan kebersihan pembersihan. Penyelidikan ini bertujuan untuk menambah baik dua kaedah pembersihan mekanikal, berputar dan merendam. Kaedah Taguchi digunakan untuk mereka bentuk dan mengoptimumkan persediaan parameter keseluruhan. Set parameter dioptimumkan yang dipilih kemudiannya akan diuji untuk menentukan set parameter terbaik. Untuk kajian semasa, proses pembasahan EBN mempunyai tetapan masa 12, 18, dan 24 jam. Tetapan masa kaedah berputar ialah

30, 45, dan 60 saat. Masa rendaman boleh ditetapkan kepada 2, 4, atau 6 minit. Setiap parameter ini diuji dengan teliti untuk menentukan yang terbaik dioptimumkan. Percubaan Kumudini dijalankan dengan menggabungkan dua parameter yang dipilih dalam urutan untuk menentukan kebersihan EBN mentah. Mengikut keputusan eksperimen, urutan pembersihan menyumbang 63.75 peratus kebersihan pada masa pembersihan selama 5 minit, termasuk masa rendaman selama 4 minit dan kaedah berputar selama 60 saat.

Kata kunci: Berputar, rendam, sarang burung yang boleh dimakan, kaedah taguchi, pengoptimuman

1.0 INTRODUCTION

EBN is a biological product of dried sticky substances released from the salivary glands of wide varieties of small swifts of the genus Collocalia that populate South East Asia (ASEAN) and neighboring islands. These nests can be found in various products, including gelatinous tonics, soups, sweets, and pure drinking [1]. EBN's origins can be traced back thousands of years. Birds' Nest, also known as Swallow Nest (SN), was discovered in China during the Tang Dynasty (618-907 CE) and is a highly valued medicinal food [2]. According to the Traditional Chinese Medicine (TCM) Book on Healthy Food, Admiral Cheng Ho brought the valuable bird's nest into China from ASEAN to the Chinese emperor over 500 years ago [3]. Since then, ancient Chinese women have used bird nests to maintain beauty and health.

EBN is a dietary supplement derived from the salivary secretions of specific swiftlets such as Aerodramus Maximus and Aerodramus fuciphagus. It is high in nutrients such as proteins, carbohydrates, minerals, amino acids, fiber, vitamins, hormones, fatty acids, and so on. EBN has also shown several medical and therapeutic effects, including antioxidant, anti-inflammatory, bone strength improvement, skin whitening, and epidermal growth stimulation [4]. EBN can be classified using physical, geographical, and quality criteria [3]. Figure 1 depicts a comprehensive guide to bird nest classification.

By focusing on Figure 1 quality criteria, it is essential to keep the quality of EBN by thoroughly cleaning it. The purer the EBN, the higher the grade. The higher the grade, the higher the cost and quality [5]. As a result, the cleaning process is critical in producing higher-grade EBN. Impurities are the most important thing to clean during the cleaning process. Inside the EBN, impurities such as feathers, grime, and small sands bind together, making cleaning difficult [6]. A conventional cleaning procedure was used to clean the EBN. Raw EBN are the uncleaned bird nest that consisits of impurities inside it. The four steps in the traditional procedure are soaking raw EBN, cleaning raw EBN, reshaping cleaned EBN, and drying cleaned EBN. One of the oldest cleaning processes in the EBN sector is conventional cleaning. However, cleaning one EBN using the traditional way takes around an hour [7].

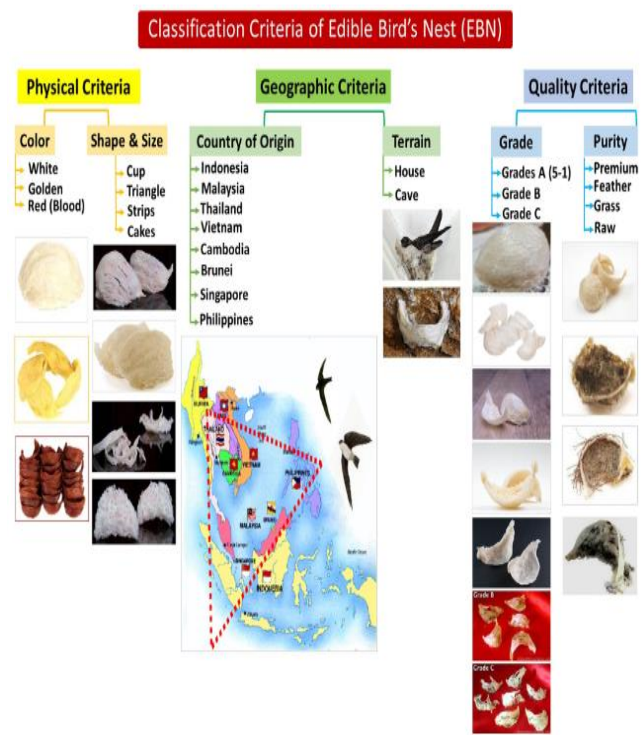


Figure 1 The Through Guide to the Classification of Bird's Nests [3]

Cleaning the EBN requires a significant amount of effort to increase output. Specific mechanical cleaning techniques for raw EBN have been introduced to avoid this problem. In today's mechanical cleaning systems, cleaning approaches such as rotating and soaking are used. However, current cleaning processes have yet to completely cover the entire bird nest, particularly the complex pollutants. As a result, the primary goal of this project is to improve mechanical cleaning processes to achieve higher cleanliness while cleaning raw EBN in less time. Testing mechanical cleaning techniques such as brushing and bubble mechanisms has been conducted to achieve better cleaning time and cleanliness [8]. Therefore, this study focuses on soaking and rotating mechanical cleaning mechanisms.

Before cleaning the EBNs with mechanical cleaning mechanisms, a wetting process must be performed. The EBN is subjected to the "wetting procedure," which entails wrapping it in a damp cloth and placing it in the refrigerator overnight. As a result of this treatment, the raw EBN will become softer, making cleaning easier.

Because it considers the cost of producing bird nests as well as time management, this research is critical to improving humanity. The cleaning system must improve as the quality of the bird nests is maintained. We can choose from various cleaning methods provided by the EBN cleaning machine, saving us time and money. Previous research has concentrated on EBN nutrients. A recent study, on the other hand, will provide information on the transportable raw EBN cleaning device. As a result, this project aims to reduce both the time and money required to clean the bird nests. Furthermore, the technique used in the industry to clean bird nests is always kept a closely guarded secret. Because of this study, everyone, especially consumers, will be aware of the cleaning mechanism. This effort will also provide an opportunity for Small and Medium Enterprise (SME) bird's nest businesses to learn about a new cleaning method that will benefit them by reducing cleaning time and expenses while increasing earnings. Finally, the findings of this study will serve as a guide and future source of information for researchers studying the mechanical characteristics of bird nests during the cleaning process.

This mechanical cleaning technique for raw EBN is explicitly designed for small and medium-sized businesses, as the currently available on the market are designed for large manufacturing enterprises and are pretty significant [9]. Many small business owners have struggled to afford these expensive cleaning methods. Hence, this mechanical technique will help to solve this problem. They can afford this device because it has a reasonable market price [8]. This technique is also portable, as it can be transported to any location at any time. Because cleaning the EBN only a tiny amount of water and electricity, these techniques are considered environmentally friendly. Green technology consumes less energy and raw materials, reduces effluent pollutants, recycles waste products, and disposes of garbage more environmentally friendly [10]. The impurities gathered during the cleaning procedure will not harm the environment because they are mostly made up of feathers, dirt, and fine sand particles. Soaking and rotating methods are the two current mechanical cleaning techniques used to clean raw EBN. Hence, these mechanical techniques are introduced by combining them to clean the raw EBN.

The previous research used two new mechanical cleaning techniques, brushing and bubbles, to clean raw EBN. In bubble cleaning, when liquids and gases are combined under pressure, they produce bubbles of varying sizes, which are used in the microbubble and bubble cleaning processes [11]. Cleaning EBN micromaterials with microbubble technology is extremely effective. Microbubbles were thought to be negatively charged, attracting positively charged impurities like dust, egg shells, and feathers. Under water pressure, these also break, resulting in shock waves. As the bubbles collapsed, the cleaning solution rushed to clean the nest area. [8]. The brushing technique is a brushing and robotic arm combination. The brush will rotate on the surface of the EBN, causing some impurities to be washed away by the contact between the raw EBN and the rotating brush. The advanced technology system will improve the efficiency of the raw EBN cleaning technique [8].

Automation and machine vision has been widely used in industry to increase output while decreasing labor costs [12]. Even though an automated inspection system to help clean EBN is still largely underdeveloped, using machine inspection to locate impurities in EBN can help lower costs while increasing cleaning process productivity [13]. Because most cleaning methods on the market are intended for large manufacturing organizations and are quite significant, this mechanical cleaning procedure for raw EBN is expressly intended for small and medium-sized businesses. [14]. The machines on the market are currently expensive, and many SME business owners have had difficulty affording one to use for cleaning raw EBN. According to statistics, these machines can clean up to 7 kilograms, or 8750 pieces of EBN, at a time. Table 1 shows EBN's average annual production. An average of 11.97kg of EBN is being harvested in a swiftlet house. This is a large amount of production which indicates the EBN industry is keep growing.

Table 1 Average Annual Production of EBN [15]

Types of premises	Shop House	Dedicated House	Average
Average area square foot	1800	5268	-
Average yield/square foot	7.28 g	2.06 g	4.67 g
Average Annual yield (Kg)/house	13.10 kg	10.85 kg	11.97 kg
Quarterly sales volume	4 kg	3.5 kg	-
Lowest production volume (% population)	≤ 0.5 kg (50)	≤ 0.5 kg (40)	-
Highest production volume (% population)	≥ 10 kg (5)	≥ 10 kg (5)	-

Given that SME business owners frequently capture far fewer EBN, this amount appears excessive for them. As a result, spending so much money on a machine to make money is a difficult decision for them. Hence, this mechanical method will help to solve all of their problems. They will be able to purchase this device due to its competitive pricing. Because it is portable, this gadget can be carried to any location at any time. The two mechanical methods currently used to clean raw EBN are the rotating method and the soaking process.

In the soaking process, the collected EBN is soaked in distilled water, followed by manually removing dirt, feathers, and eggshells with forceps [16]. This step softens the EBN. Because the EBN expands after soaking in water, dust and other lighter contaminants can be easily extracted with forceps [17]. Figure 2 depicts the EBN being immersed in water.

Figure 2 EBN soaked inside the water [17]

The rotating method is described as an oscillator which is a system that oscillates back and forth around a pivot point [18]. It is quantified in terms of amplitude and cyclical time for one complete oscillation or cycle [19]. An oscillating rotation system alternates between clockwise and counterclockwise rotations [18]. This technique can replace the stirrer following the installation of the raw EBN. The system must be shaken and rotated 180 degrees. It will be possible to prevent the EBN from disintegrating in this manner.

2.0 METHODOLOGY

The steps in the methodology were to set up the optimum cleaning parameters, optimize the EBN mechanical cleaning methods, and validate the suggested parameters using experimental data.

Experimental Setup for EBN Wetting Process

The raw EBN will be refrigerated while wrapped in a moist cloth for 24 hours. This procedure aims to soften the raw EBN so it can be cleaned later. Following the wetting process, the specimens will be placed inside the EBN compartment for cleaning. The purpose of this experiment was to analyses cleanliness by weighing EBN before and after the experiment. We can calculate the removal rate of each specimen using this formula. In contrast, Equation 1 shows the removal rate calculation.

"Removal Rate " ("g/min") = ((Wu-Wc)) /t,   (Eq.1)

where Wu is the weight of unclean EBN (g), Wc is the weight of clean EBN (g), and t is the time (min).

Standard of Procedure (SOP) of Wetting Process of Raw EBN

Table 2 shows the procedure for conducting the experiment.

Table 2 SOP of EBN Wetting Process Set Up

No	Procedure	Image
1	A wet cloth was placed inside a box.	
2	Three specimens were prepared for each time settings to be analyzed.	
3	The specimens were placed on a wet cloth inside a box, and the box was placed inside the refrigerator.	
4	The time setting for the wetting process was 24 hours.	
5	After the wetting process, the EBN was placed inside the compartment for the following cleaning process.	

Experimental Setup for Soaking Process

EBN was immersed in water for several hours to remove extra feathers from the nest [20]. Dirt and feathers, for example, will generally rise to the surface and be removed. Due to the fermentation of bird soil which are bird dropping, nitrate concentrations in raw EBN increased significantly. A high nitrate intake may harm humans because it is the primary source of nitrite via bacterial or microbial reduction nest [21]. Therefore, the nitrate concentration in raw EBN can be reduced during the soaking process. Raw EBN was soaked in water for 2, 4, and 6 minutes. The weight of EBN was recorded before and after the experiment to determine the cleanliness. We can calculate the removal rate of each specimen using the formula from Equation 1 above. Figure 2 shows the experimental setup for EBN cleaning. The outer ring will be filled with water before the specimens are placed for cleaning.

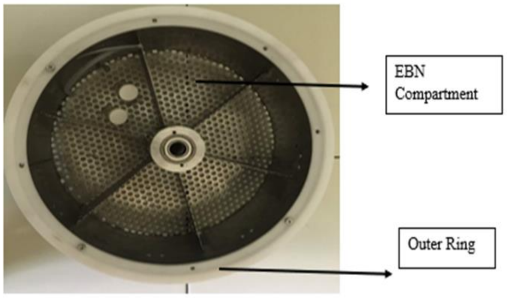


Figure 3 Experimental Setup for EBN Cleaning

Standard of Procedure (SOP) of Soaking Process

The Soaking process softens the raw EBN for cleaning. The EBN was wrapped in a damp cloth and refrigerated for 24 hours. Table 2 shows the experimental procedure.

Table 1 SOP of Soaking Process Set Up

No	Procedure
1	Three specimens were prepared to be analyzed.
2	The specimens were placed into the EBN compartment.
3	EBN was soaked for a selected time range of 2 minutes, 4 minutes and 6 minutes, respectively.
4	The soaked EBN was removed from the water and placed on a cloth to allow the excess water to dry off before weighing it again.
5	The EBN was weighted, and the data was collected for all time ranges.
6	The data was collected and computed into a table.

Experimental Setup for Rotating Cleaning Method

Figure 3 depicts the experimental setup for the rotating cleaning method. The EBN will be placed inside the EBN compartment where the outer ring shakes in clockwise and anticlockwise directions of 180 degrees. The rotation causes vibration inside the EBN compartments, allowing the EBN to be cleaned.

Standard of Procedure (SOP) of Rotating Cleaning Method

The goal of rotating method is to shake contaminants out of the water tank. Table 3 shows the experimental procedure.

Table 2 SOP of Rotating Method Set Up

No	Procedure
1	Three specimens were prepared to be analyzed.
2	The specimens were placed into the EBN compartment.
3	The device was set to rotate under a fixed rotational angle for a selected time range.
4	The experiment is run for the selected time, after that the specimens are collected and placed onto a tissue paper for 5 minutes to allow the excess water dries out.
5	Then the EBN is weighted, the data was collected and computed into a table.

Taguchi Method

Genichi Taguchi proposed the Taguchi method in the 1960s. With time, its popularity has grown due to its unique qualities, like the reduced number of tests required to ascertain how operating factors affect product quality [22]. The product quality was greatly enhanced by this design.

The following is a step-by-step process for applying the Taguchi method.

1. Response parameters, control components, and their interactions were identified; control components were the cleaning time, and response parameters were the cleanliness.
2. Two factors and three levels for experimental parameters were selected and conveyed into a table of experimental parameters settings.
3. An appropriate orthogonal array was chosen based on the importance of each factor and the available designs.
4. The orthogonal array of L9 was selected.
5. The required data were keyed in.
6. The data's mean, signal-to-noise ratio, and variation analysis were the selected results for Taguchi Method.
7. The ideal values were analyzed for several factors.
8. The final experiment was confirmed to ensure that the experimental outcome was consistent with the prediction.

The Taguchi Method is an eight-step procedure for planning, carrying out, and analyzing matrix experiment data to determine the optimal ratios of controlling elements. It is necessary to identify the inputs that will have an impact on the outcome. The data from the optimized parameters will be analyzed with Minitab 18. The three main phases of the Taguchi technique were system design, parametric design, and tolerance design. General technological knowledge is used in system design. The goal of parametric design is to improve parameter sets. Tolerance design is the process of determining the tolerance of ideal parameters. The Taguchi Method was divided into three components: factors, levels, and reactions. The response is the experiment's outcome next [8].

Two factors in these experiments were the soaking process and the rotation method. Each factor has three levels of customization, while the soaking time was set to be 2, 4, or 6 minutes. The rotating method has timer settings of 30, 45, and 60 seconds.

The selected parameters for conducting the Taguchi Method were identified based on the insights gained through engagement with SMEs. The signal-to-noise (S/N) ratio was used to determine the best cleaning parameters. The Taguchi technique can evaluate the performance of cleaning methods using the S/N ratio. It shows the variety of criteria that were being considered. The information was presented as an average to standard deviation. It is possible on a case-by-case basis due to using an objective function. The Larger is Better (LB) criteria. According to the LB criteria, the highest point of the graph has the most significant effect on the experiment. The greatest impact of a factor indicates that it has the most significant influence on the answer. The mathematical form of the LB criteria is

$$= 10 \log \frac{1}{n} \left(\sum y^2 \right) \qquad \text{(Eq. 2)}$$

where y is the observed response value, and n is the number of replications.

The data from the signal-to-noise S/N ratio will be used to create the graph and table. The best EBN cleaning method settings will be displayed. An analysis of variance will then be used to estimate the contribution of significant parameters to the quality response (ANOVA).

The Taguchi Method was used to reduce the number of tests required. Experiments involving parameter soaking and rotation will be carried out to collect data on each parameter over a specified period. After collecting the data, the next step was running parameter tests with different time combinations to determine the best parameter for cleaning raw EBN. This step allows us to collect the results of combining two different parameters, soaking and rotating processes with varying periods. As a result, the Taguchi Method was used to obtain results without conducting tests to reduce the number of experiments performed. The Taguchi Method saves time and resources.

Validation of Optimised Parameter Set

After optimizing the chosen parameters, they will be tested in a sequence with the best cleaning parameter set from Taguchi Method. The experiment will be carried out using the sequence of 2 cleaning parameters to find the cleanliness of the cleaning process. Equation 3 is the formula for calculating the cleanliness.

$$\text{*\% of Cleanliness} = \frac{\text{Weight loss (before−after)}}{\text{Total weight loss}} \times 100 \text{ X } 90\% \text{ (10\% of loss weightage)}$$

. (Eq. 3)

(Taken 10% of loss weightage of EBN is dissolved in water.)

As the raw EBN was soaked, small contaminants such as sand and dirt dissolved in the water. The soaking process reduced the nitrate concentration in raw EBN. This process eventually accounted for around 10% of the total weight of raw EBN nest [23].

3.0 RESULTS AND DISCUSSION

The methodology's instructions carried out all experiments. In studies, various parameters were tested, including the rotating method and the soaking process. The Taguchi Method was then used to optimize the results obtained. After the Taguchi Method is completed, the result table and graph will be displayed, and the most preferred parameter set for EBN cleaning will be identified.

Results of Soaking Process on Cleanliness

The raw EBN was immersed in water for the specified time in this experiment. Soaking will help the EBN expand, and because the expansion creates space between the impurities and the EBN, some of the impurities will naturally be cleansed. As a result, lighter impurities will float in the water, while denser ones will settle at the bottom.

Table 3 Water Absorption of the EBN on Selected Time

Time	2 minutes	4 minutes	6 minutes
Weight of dry EBN (g)	1.73	1.28	1.44
Weight of wet EBN (g)	3.10	3.35	4.73
Water Absorption, %	79.19	161.72	228.47

Table 4 depicts the EBN's water absorption over time. Three specimens were tested at each period, and the table below shows the average value of the three specimens.

Table 5 Removal Rate of EBN Based on Soaking Process

Time	2 Minutes	4 Minutes	6 Minutes
Weight of raw EBN (g)	1.73	1.28	1.44
Weight of cleaned EBN (g)	1.71	1.23	1.41
Weight loss (g)	0.02	0.05	0.03
Removal Rate (g/min)	1.67×10^{-4}	2.08×10^{-4}	1.0×10^{-4}

Table 5 shows that the contaminants removed had a low removal rate. This was because the soaking process primarily focuses on expanding the EBN to allow cleaners easier access to it. Because some contaminants, such as sand, are heavier than water, they will be deposited on the bottom of the water when the EBN expands. Some EBNs still have impurities such dirt, soil and feathers attached to it, which was difficult to remove because it was found at the deep inside the dead end of the EBN surfaces. Dead end surfaces are the part of EBN where it is difficult to be cleaned. Figure 4 depicts the before and after samples of soaking process specimens. Figure 5 compares bird nests through the cleaning process, as evidenced by the difference between the before and after experiments. From figure 4, the impurities still can be seen after the experiments as the impurities failed to be cleaned under the time setting. It also seen as the EBN has expanded in size after soaked inside water.

I) Specimens at 2 minutes

Specimen	Before	After
1		
2		
3		

II) Specimens at 4 minutes

Specimen	Before	After
1		
2		
3		

III) Specimens at 6 minutes

Specimen	Before	After
1		
2		
3		

Figure 4 Sample of the EBN Specimen of Soaking Process

Results of Rotating Methods on Cleanliness

The rotating method removes impurities through vibration by rotating the water tank. There was some debate about the removal rate in terms of cleaning time. Figure 5 depicts the sample of the EBN specimen for the rotating cleaning method before and after the experiment. Three specimens were tested at each time, and the table below shows the average value of the three specimens. Table 6 shows the experiments' most notable effect of the rotating cleaning methods.

Table 6 Removal Rate of EBN Based on Rotating Method

Time	30 seconds	45 seconds	60 seconds
Weight of raw EBN (g)	2.33	2.49	2.36
Weight of cleaned EBN (g)	2.32	2.47	2.33
Weight loss (g)	0.01	0.02	0.03
Removal Rate (g/min)	$2x10^{-2}$	$2.67x10^{-2}$	$3.0x10^{-2}$

According to above Table 6, the average removal rate was $2x10^{-2}$ g/min for 30 seconds, $2.67x10^{-2}$ g/min for 45 seconds, and $3.0x10^{-2}$ g/min for

60 seconds. As a result, it has been demonstrated that this cleaning method aids in the purification of raw EBN. The rotating method has an impact on the cleaning of raw EBN. In figure 5, there are still some impurities trapped inside the EBN while cleaning as can be seen in pictures of after column. The impurities tend to be sticked together with the EBN hence makes the cleaning to be difficult.

I) Specimens at 30 second

Specimen	Before	After
1		
2		
3		

II) Specimens at 45 seconds

Specimen	Before	After
1		
2		
3		

III) Specimens at 60 seconds

Specimen	Before	After
1		
2		
3		

Figure 5 Samples of the EBN Specimen of Rotating Method

The impurities removal rate of EBN was affected by the two cleaning parameters rotating method, and the soaking process. The rotating method, followed by the soaking process, was vital in EBN cleaning. The validation by experiment method was used to determine the best fit parameter set for EBN cleaning based on the experimental results.

Optimisation of the Parameters

The chosen parameters will be optimized with the Taguchi method. The primary purpose of the Taguchi method was to reduce the number of experiments required when the same combination of elements occurs on multiple occasions. The two elements were the soaking process and the rotating method. These tests were performed according to the L9 orthogonal matrix, which contains three level differences for each factor, as shown in Table 7. Table 8 shows the design summary for the Taguchi Method in Minitab18 software.

Table 7 Experimental Parameters and Levels

Factors	Level 1	Level 2	Level 3
A: Rotating Method (Sec)	30	45	60
B: Soaking Process (Min)	2	4	6

Table 8 Design Summary of Taguchi Method

Soaking(min)	Rotating (sec)	Data
2	30	0.02138
2	45	0.02803
2	60	0.03133
4	30	0.02167
4	45	0.02837
4	60	0.03167
6	30	0.02067
6	45	0.02737
6	60	0.03067

Table 9 displays the response table for the parameters used in EBN cleaning. The delta value in the response table depicts the variation in response from level 1 to level 3.

Table 9 Response Table for Signal to Noise Ratic

Level	Soaking	Rotating
1	31.51	33.46
2	31.40	31.08
3	31.74	30.11
Delta	0.33	3.35
Rank	2	1

Furthermore, it demonstrates that the parameter's influence on the cleaning process grows with value. The importance of each fundamental parameter was indicated by its rank. The rank column displays the importance of each parameter. The response graph in figure 6 was created using the delta value to select the best EBN cleaning parameters. The section data in Table 9 is the EBN removal rate calculated using Equation 1 mentioned above.

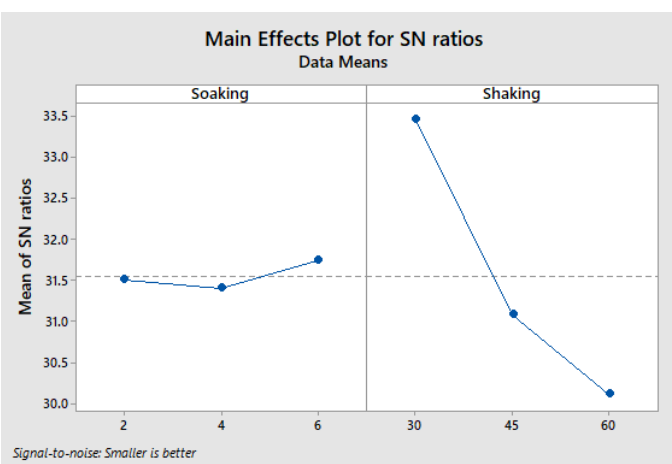


Figure 6 Response Graph for Removal Rate of Basic Parameters

Table 10 shows the analysis of variance from the Taguchi Method as these components' F-values were higher than the statistical table value, $F_{0.05,\ 2,\ 8} = 4.46$, which was regarded as having a 95% significant level of confidence. Thus, it was established that the rotating method has the most significant effects on cleaning raw EBN, followed by the soaking process.

Table 10 Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Regression	2	0.00150	0.00075	68.26	0.000
Soaking	2	0.00001	0.00001	0.62	0.460
Rotating	2	0.00150	0.00150	135.91	0.000
Error	0	0.00007	0.00001		
Total	4	0.00157			

Validation of Proposed Parameter Set

A sequence was tested to develop the optimal parameter set capable of producing the highest cleanliness percentage in the shortest time. Table 11 shows the sequence that will be tested with the available time. The experiment has been carried out for each sequence. This cleaning process for raw EBN includes the soaking process and the rotating method. Each of these methods will significantly impact the cleaning of raw EBN by removing impurities. This method has been shown to effectively and efficiently clean raw EBN. The EBN will dissolve in a water solution, which can be viewed as one of the weight losses; thus, a 10% weightage loss will be included in the final computation.

Table 11 The sequence of the EBN Cleaning Process

Process	Time
Soaking	4 min
Rotating	60 sec
Weight (Before), g	1.65
Weight (After), g	1.48
Weight Loss, g	0.17
After Manual Cleaning, g	1.41
Total Weight Loss, g	0.24
% Of Cleanliness*	63.75%

The cleanliness of cleaned EBN for the sequence is 63.75 percent. In the sequence, the first cleaning process, soaking, extended the raw EBN's soaking time, allowing the second cleaning method, rotating, to clean deeper beyond the raw EBN's dead surface in 60 seconds. The sequence was undeniably cleaner and faster to complete and successfully adjusted the two parameters, yielding a better result. Figure 7 depicts the experimental outcomes of the sequence. In Figure 7, he impurities still can be seen after the experiments as the impurities failed to be cleaned under the time setting. It also seen as the EBN has expanded in size after soaked inside water.

Specimens at sequence

Specimen	Before	After
1		
2		
3		

Figure 7 Sample of the EBN Specimen of the sequences

4.0 CONCLUSION

The current cleaning techniques of EBN, soaking, and rotating cleaning techniques have been independently tested to determine the effects of each cleaning technique on EBN cleaning. The cleanliness of the cleaning is measured. This is also done to shorten the time it takes to clean the EBN. During the time range of 60 seconds, the cleaning techniques have the highest removal rates. According to the experimental results, the rotating cleaning technique has the highest removal rate of 3.0x10-2 gram/ min, followed by the soaking method with a removal rate of 2.08x10-4 gram/min. The continual investigation of cleaning parameters will aid in the progress of its improvement. The two parameters have been validated by experimenting with a sequence that has a cleanliness of 63.75%. The sequences are soaked for 4 minutes, followed by rotating for 60 seconds.

Due to its use in the calculations to determine the cleanliness and cleaning time, the water absorption and removal rate research was crucial. The continued investigation of cleaning parameters will aid in the improvement's progress. The parameters used for this experiment were the soaking process and the rotating method. The time the EBN was soaked affects how much EBN expands during parameter soaking time. The rotation's degree of rotation and intensity were the parameters used in the rotating method. The Taguchi Method's Design of Experiment layout (DOE) was performed to determine the ideal parameter setting for the cleaning process. The ideal settings for EBN cleaning operations were chosen using the Taguchi technique. Because fewer specimens were required for the experiment, the DOE approach is efficient.

Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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