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Recycling Waste Activated Carbon from Food Additive Industry into Biocharcoal Briquettes with PDCA-Taguchi Integration (Project: PT. XZY)

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ABSTRACT: PT XZY is a company engaged in the field of Food Additives (BTP) in the form of vetsin from molasses raw materials. The company in exploiting energy resources on a large scale for the development of its industry has an impact on the environment in the form of industrial waste caused by the production process, namely waste active carbon generated from the adsorption of inline products. The existing problem is the remaining waste carbon in the solar dryer and the industry does not get added value. The processing strategy uses PDCA-taguchi integration. The PDCA cycle effectively identifies problems with an approach that refers to the Responsible Waste Management Hierarchy and is limited to carrying out recycling experiments. While the experimental design uses taguchi because it is more cost effective than other DOEs. This research is a descriptive and experimental quantitative method. Project implementation by identifying problems using the PDCA eight-step tool. Recycling concept by designing taguchi experimental arrangement. So that the recycling optimization design is obtained, namely dry waste carbon; [adhesive]: 25%; pressure: 2 minutes. The evaluation results at step 7 of PDCA are obtaining an added value of 3.0% (Rp. 29,093,376.84 / year from a total of 150 kg of briquettes / day) NPV value> project cost (+) of Rp. 110,286,788.00, BEP value of Rp. 770,740,120.01 and ROI of 15.6%.

KEYWORDS: Biocharcoal Briquettes, Food Additives , PDCA, Taguchi optimization, Recycle , Feasibility of Business (NPV, BEP, ROI).

I. INTRODUCTION

The use of Food Additives (BTP) in food processing has been a topic of concern in various studies. Based on a list released by the Food and Drug Monitoring Agency (BPOM), the Food Additives industry includes the business of making seasonings such as curry spices, curry spices, pepper spices, ginger powder, nutmeg powder, chili powder and others. This also includes the business of the cooking flavoring industry such as vetsin (MNG), vanilla powder and other seasoning industries (Badan POM RI, 2022). This food sector industry has the potential to make continuous improvements in both the production process, optimizing resources by reducing waste, resulting in greater cost savings and efficiency.

The mononatrium glutamate (MNG) industry is one of the BTP industries. MNG is a flavor enhancer known as vetsin that is widely used in the food industry. This company in exploiting energy resources on a large scale in the development of its industry has an impact on the environment, namely in the form of waste activated carbon produced from the adsorption of inline products in the form of a neutral solution (neutralizer liquor). The adsorption process is a series of MSG solution purification processes to produce a clear solution that is ready to be crystallized into MSG solids. The problem that arises is the waste carbon generated from the production process which will pollute the environment and also the Solar Dryer is not adequate. Based on Government Regulation (PP) Number 22 of 2021 concerning the Implementation of Environmental Protection and Management, waste carbon has an impact on environmental pollution if not managed properly. The following is the total waste carbon data generated from the production process and the remaining carbon in the Solar Dryer from 2019 to 2023.

Figure 01. Total waste carbon in the Solar Dryer from 2019 to 2023
(Source: processed by the author, 2024)

Previous research with the PDCA cycle approach has been used effectively in various industries to reduce waste and improve processes. In the automotive sector, the method was used to optimize internal logistics resulting in reduced transportation waste and improved stock management (Amaral et al., 2022). Similarly, in the battery industry the PDCA method was used to manage atmospheric emissions and waste disposal leading to the proposal of a sustainable management model (Arenhardt et al., 2018). In the water supply sector, Lean Service was implemented using PDCA to reduce waste in the installation of new pipe connections (Irawan et al., 2020). Finally, the PDCA cycle was applied in the packaging industry to improve the quality and sustainability of packaging materials and methods (Nguyen et a.l, 2020). These studies collectively demonstrate the versatility and effectiveness of the PDCA cycle in waste reduction and process improvement in various industries.

The Taguchi method, which is part of Design of Experiment, was used in this study because it plays an important role in achieving high quality at minimal cost (Irnanto et al., 2024). Design of Experiment is a process that involves treating an object to understand its impact under controlled conditions. This method aims to improve product quality and efficiency in the production process. According to Bagchi (2013) in Anggra S Irnanto et al. (2024) Taguchi method focuses on improving process capability and reducing variation in production. By identifying optimal factors and levels, this method allows a reduction in the number of experiments, making it more time- and cost-efficient (Muharom et al., 2015). The result is a combination of factors and levels that is resistant to interference or noise (Liu et al., 2019). The application of Taguchi methods allows companies to achieve improved product quality with more efficient use of resources and produce products that are more stable to external variations compared to other methods such as full or partial factorial, complete randomized design, complete randomized block, and latin square. Therefore, with this research gap and to overcome the waste problems of PT XZY, research is needed on the optimization strategy for processing carbon waste with the recycle principle to increase added value.

II. METHODS

This research will use descriptive and experimental quantitative methods to describe, explain, or summarise various conditions, phenomena, or research variables obtained through observations, interviews, and experiments. The data required includes primary data from the results of focus group discussions (FGDs), brainstorming with the Plant Head and GA Manager, and direct observation of the Solar Dryer unit. In addition, secondary data required include carbon quality parameters, production processes, costs required, and several journals related to waste treatment. This research will be conducted in the operational area of PT XZY in East Java with the aim of optimising waste carbon treatment by recycling. The object of this research is waste carbon generated from the production process. The study population consists of waste carbon in the Solar Dryer in the storage area. The sampling process begins with determining the area of the Solar Dryer to divide several sampling points. The solids sampling technique follows SNI 19-0428-1998. Sampling is carried out with variations in storage time, where samples are taken from several points of the area, then mixed into one mixed sample. This mixed sample is then used as the primary sample. In this study, experiments will be conducted on wet and dry samples.

The research steps generally use the PDCA method then in the Check stage integrate the recycling principle with taguchi experiments. The description of the research flow diagram with 8 PDCA steps, namely

1. **Plan** is **step 1**: planning by determining the background of waste carbon problems obtained from field studies and combining literature studies. The existing background is identified both internal factory factors such as limited solar dryers, no added value, single vendors and high carbon prices, while external factors are reflecting on the environment if not handled properly, the lack of 3rd parties who accommodate and others. The identification can be done through FGD (Focus Group Disscusion) tools, brainstorming, check sheets or histograms. After identifying the existing problems, determine the problem formulation, objectives and limitations. **In stage 2**: setting targets by increasing added value using the SMART method. **Step 3 and 4**: Genba and cause and effect analysis using fishbone diagram, then **step 5**: using 5W + 1 H to plan and identify potential waste carbon processing.

2. **Do** is implementing what has been planned at the Plan stage. **In step 6**: conduct experiments related to processing strategies then integrate the 3 R principles (reduce, reuse and recyle) by conducting experiments related to the solutions that have been identified. The experimental design was carried out with Taguchi to get the best variables. Then after identifying the processing potential, enter the Check stage.
3. **Check** is the **7th step**: checking by analyzing the results of taguchi to get the best composition variation. These results are then used to develop a business feasibility analysis (NPV, BEP and ROI).
4. **Action** is the **8th step** by following up on the best solution by evaluating the results, standardizing and planning further improvements.

III. RESULT AND DISCUSSION

A. *Plan* Stage

At this stage, according to Nguyen et al (2020), it consists of 5 steps to identify problems, set goals, analyze existing conditions, analyze the causes of problems and plan and identify processing.

1. Step 1: Determining the Theme/Problem.

The results of research related to the determination of existing themes or problems can be described as follows:

- *Branstorming*

  Branstorming with the Plant Head of PT XZY on April 15, 2024 at 14.00 WIB. Several questions were asked by researchers related to what were the problems of the factory environment. The brainstorming results conveyed problems based on PQCSDME (Productivity, Quality, Cost, Safety and Service, Delivery, Morale, Environment). The main focus is on CE (cost and environment) issues, where the future challenges are to reduce production costs and how to make the industry environmentally friendly in order to realize Green Industry. Brainstorming was also carried out with the GA (Ganeral Affair) Manager on April 14, 2024 at 13.00 WIB until completion. The results of the interview conveyed how to process waste solids into added value for the industry, previous research related to waste solids in the form of waste carbon made into biocharcoal briquettes has been carried out at the QCC competition in 2023. This is an opportunity for researchers to continue previous research.
- *FGD (Focus Group Discussion)*

  The FGD was held on Monday, May 13, 2024 and the results of the FGD became a reference for formulating issues about waste carbon. The results of the FGD explain in detail the condition of waste, expectations of utilization and also demands for the results of waste to a minimum. Focus Group Discussion was conducted with 6 main team members who became mentors of the QCC project th. 2024.
- Histogram and Pareto

  Identification of external factors is obtained from the total waste disposed of during the production process. The total waste discarded is shown in graph 02 of the histogram below:

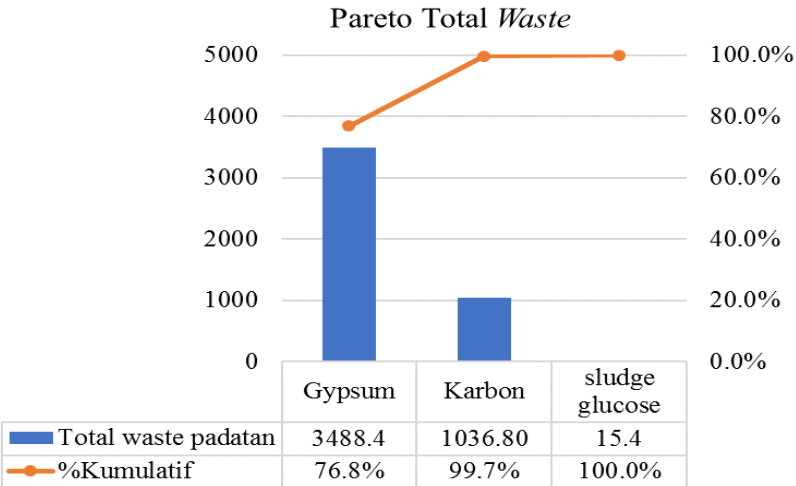

Figure 02. Pareto total waste discarded
(Source: processed by the author, 2024)

According to Vilfredo Pareto, the Pareto principle is a theory that says that as much as 80 percent of the output of a system or certain conditions will depend on 20 percent of the input. In graph 01, what needs to be handled is gypsum and carbon. Gypsum at

PT WXYZ has been utilized by third parties and has added value. At the problem determination stage, the research results can be concluded, namely :

1. Branstorming based on PQCSDME (productivity, quality, cost, safety and service, delivery, morale, environment). The main focus is on CE (cost and environment) waste processing problems.
2. Focus Group Discussion by 6 teams with continuing QCC in th. 2024.
3. Potential loss due to waste (waste loss cost)
4. Policy Dept. Activity's policy of 20% cost reduction
5. Active carbon waste handling strategy with a cumulative 99.7% on the Pareto diagram.

2. Step 2: Determining Targets

In the previous step in determining the theme, it was stated that how to reduce active carbon waste. Therefore, a targeted and measurable processing strategy is needed so as to obtain added value for the industry. The target setting is described based on SMART rules (specific, measurable, achievable, reasonable, and time base), namely:

1. Specific, namely there is a CE (Cost and Environment) problem in waste carbon processing.
2. Measurable, namely the potential for increasing the added value of waste carbon min. 15%.
3. Achievable, namely the ability of researchers to contribute to kaizen.
4. Reasonable, namely policy dept. activity cost reduction of 20%.
5. Time base yaitu penelitian yang direncanakan selesai Juli 2024.

An overview of target setting is shown in **chart 03** below:

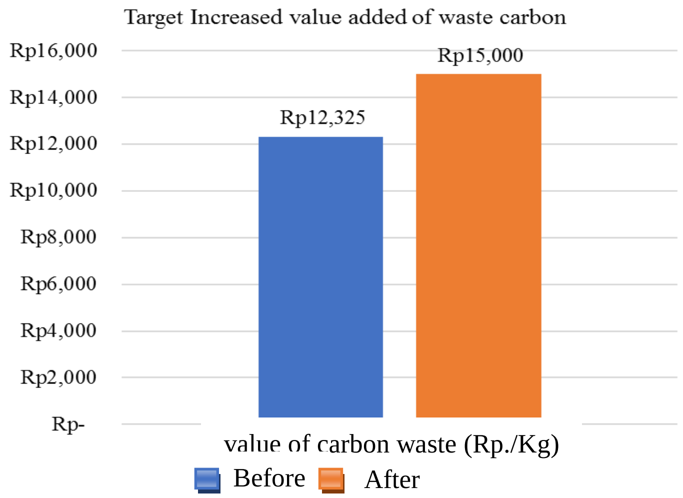

Figure 03. Total increased value added of waste carbon
(Source: processed by the author, 2024)

3. Step 3: Current Condition Analysis

In the third step in the plan section is to analyze existing conditions (Anakonda). Research conducted by Yonatan et al (2015) to analyze existing conditions is an analysis by coming directly (genba). Genba by directly observing what conditions are potential waste carbon problems that do not have added value to the industry. Genba was carried out for 5 days, namely on May 20 to 24, 2024 at several locations related to carbon. The results of the genba findings are shown in table 01 below.

Table 01. Genba finding results

Location	Genba's findings
Purchasing	The carbon vendor that sends to PT WXYZ is the main vendor from PT SM.
Solar Dryer	1. Inadequate waste carbon storage 2. Waste carbon cannot be stored for too long, shelf life max. 90 days. 3. There are limited 3rd parties that accommodate or purchase carbon. 4. Low selling value.

(Source: processed by the author, 2024)

4. Step 4: Problem Cause Analysis

The fourth stage in the plan section is to conduct a cause and effect analysis that is expected to find the root cause of waste carbon that has no added value to the industry. This analysis is made based on the results of analyzing current conditions, discussions with the QCC team, production supervisor and general affair manager. The cause and effect analysis will discuss the potential problems of waste carbon from the process and storage stages in the Solar Dryer. This is because it is considered a critical process that must be controlled / carried out processing strategies. Figure 04 below is a cause and effect diagram

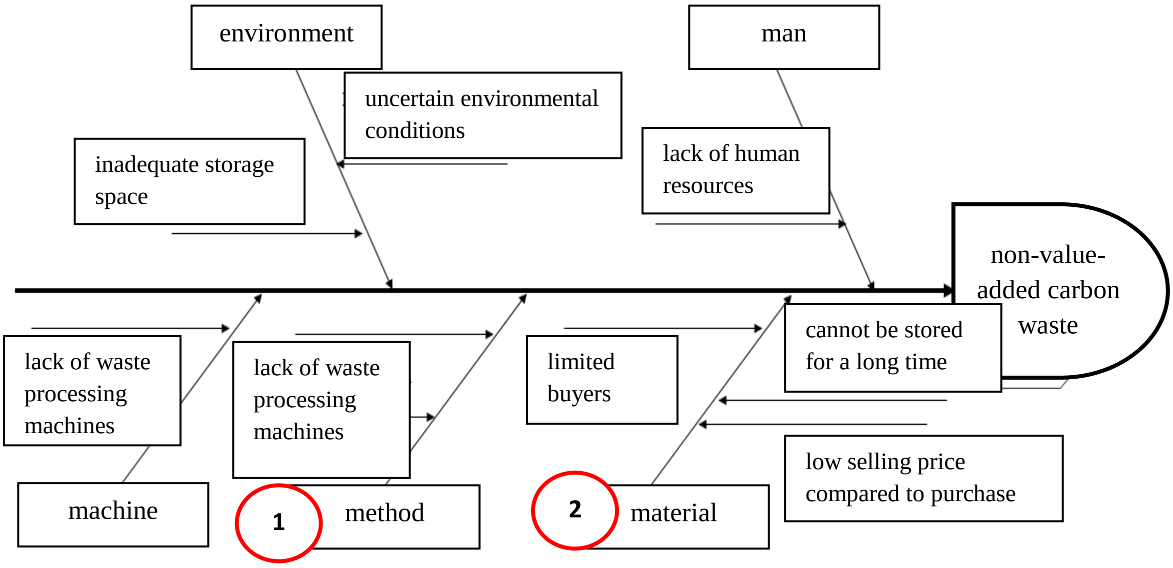

Figure 04. Cause and effect diagram
(Source: processed by the author, 2024)

The solution to the above problems is limited in terms of materials and methods, namely by processing with the 3 R approach (reduce, reuse and recycle) using literature studies.

5. Step 5: Plan and Identify Processing

At this stage, in accordance with the regulations regarding the reduction of waste or solid waste through the 3R according to Law Number 18 of 2008 concerning Waste Management includes:

1. Limitation (reduce): striving to produce as little waste as possible.
2. Reuse: if waste is finally formed, then try to utilize the waste directly.
3. Recycle: residue or waste that remains or cannot be utilized directly, then processed or processed to be utilized, either as raw materials or as a source of energy.

Based on the letter of operational feasibility of B3 waste treatment for PT XZY B3 waste utilization activities in the Ministry of Environment letter Number 5.756 / Menihk-PsLB3 / UPLB3 / PL8.31512021 dated 01 April 2016 states that Carbon Waste can be utilized or reprocessed. Recycling of carbon waste is to process the remaining residue as raw material for other products into biochar briquettes. Methods used Taguchi experiment with orthogonal array L4.

B. *Do* Stage

The next stage is the steps taken in the form of activities by making the processing process flow, designing the optimization process, collecting tools and materials, conducting pilot plant experiments for waste carbon processing. At the implementation stage (Do), by conducting laboratory scale experiments as a representative scale process. The level of confidence in applying the results of laboratory-scale experiments to industrial scale varies greatly and depends on various factors, including the type of process or product, the complexity of the system, and the similarity of conditions between the laboratory and industry.

6. Step 6: Implementation of Processing Strategy

The selection of biochar briquette quality optimization to be studied is in accordance with SNI 01-6235-2000 quality standards, among others:

Table 02. Wood charcoal briquette standard

No	Test Type	Unit	Requirements
1	Moisture content	%	Max. 8
2	Loss on heating at 90°C	%	Max. 15
3	Ash Content	%	Max. 8
4	Calorie	Kal/gr	Min. 5000

(Source: SNI 01-6235-2000)

The selection of biochar briquette quality optimisation to be studied is based on the SNI 01-6235-2000 quality standard. In this research, the test parameter is moisture content. The smaller the moisture content the better (small-the-better or STB). Identifying and selecting factors that can affect the quality of biochar briquettes. The factors used in this study are as follows: The main raw materials used consist of wet and dry waste carbon. There are two factor levels representing two different types of materials.

a. The adhesive used was tapioca. The adhesive ratio shows the effect of adhesive concentration on the weight of raw materials, where an increase in adhesive concentration will increase the moisture content in the briquettes. There are two factor levels of adhesive concentration, namely 25% and 40%.
b. The felt pressure in this study was done manually, so the variable controlled was the length of pressure. The duration of the pressure affects the quality of the biochar briquettes produced. Loading affects the moisture content, where the moisture content tends to decrease with increasing pressure duration. There are two factor levels, 2 minutes and 5 minutes.
c. Material storage conditions cannot be controlled. There are two levels, namely old or new material storage conditions.

Establish the controlled factors and noise factors, as well as determine the level of each of them.

Table 03. Standard of wood charcoal briquettes

Code	Controll Factor	Lv.1	Lv.2
A	Briquette raw material	Dry WC	Wet *WC*
B	Adhesive concentration	40%	25%
C	Long pressure Felts	2 menit	5 menit

Table 04. Noise factor and level

Code	Noise Factor	Lv.1	Lv.2
D	Material storage conditions	Old	New

The selection of OA in this design is similar to that used in recycling research. Here is the basic L4 matrix used to establish the control factors:

Table 05. Standard L4 Orthogonal Array

Trial No	Columns		
	1	2	3
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

- Implementation of experiments in the process of making briquettes bioarang namely :
  1. Preparation of raw materials: the main materials used in this study are wet and dry waste carbon, which is obtained from the waste production of PT. ZYX. The total mixture is made in the amount of 1 kg.
  2. Mixing of ingredients : the first stage is to prepare the adhesive, which is tapioca. This adhesive is made by heating 2 kg of tapioca with water at a temperature of 90°C until thickened. The concentration of the adhesive used is 25% and 40%. The mixture is made in an amount of 1 kg. Next, all raw materials and adhesive are mixed. For an adhesive concentration of 25%, 250 grams of adhesive and 750 grams of raw materials are used; for a concentration of 40%, 400 grams of adhesive and 600 grams of raw materials are used. All ingredients are thoroughly stirred.
  3. Printing and drying : the mixture is then printed using a printing press, with long variations of different pressures. Drying is carried out at a temperature of 100°C for 24 hours or with outdoor storage for 2 days.

The results of experiments conducted using L4 for the inner array and L4 for the outer array aims to identify the three responses that have been mentioned previously. The experimental results showing the value of % MC of bioarang briquette are presented in table 06.

Table 06. Experimental results data variable response value %MC

				L4 OA (Outer Array)			
				D			
	L4 IA (Inner Array)			1		2	
	A	B	C	%MC			
	Column Number			Y1		Y2	
Ex	1	2	3				
1	1	1	1	9.4	8.3	10.5	9.9
2	1	2	2	7.5	8.2	8.1	7.7
3	2	1	2	14.4	14.2	16.0	16.9
4	2	2	1	11.4	12.4	12.5	10.5

				L4 OA (Outer Array)			
				D			
	L4 IA (Inner Array)			1		2	
	A	B	C	%MC			
	Column Number			Y1		Y2	
Ex	1	2	3				
1	1	1	1	9.4	8.3	10.5	9.9
2	1	2	2	7.5	8.2	8.1	7.7
3	2	1	2	14.4	14.2	16.0	16.9
4	2	2	1	11.4	12.4	12.5	10.5

(Source: processed by the author, 2024)

- Data processing of research results:

a. Data normality test Determining The Hypothesis :
   - H0: the Data follows a normal distribution (p-value or Sig. > 0.05)
   - H1: the Data does not follow a normal distribution (p-value or Sig. < 0.05)

   Based on the statement Singgih Santoso (2014) dalam Irnanto et al (2024), the data is considered normally distributed (symmetric) in the *Shapiro-Wilk* test if the Sig value. greater than 0.05 because the data is less than 50.

   Table 07. Output %MC for the *Shapiro-Wilk* test normality

Experiment		Shapiro-Wilk		
		Statistic	df	Sig.
%MC	Exp1	0.980	4	0.90
	Exp2	0.892	4	0.39
	Exp3	0.890	4	0.38
	Exp4	0.873	4	0.31

   The interpretation of the table above is that each experiment was performed 4 times, which is seen from the DF value for a total of 16. Statistical values range from 0 to 1, where values close to 1 indicate the data is closer to the normal distribution. Of the four experiments, the value of Sig (p-value) is greater than 0.05 which means H0 is accepted, and the water content (%MC) of the results of the study is normally distributed.

b. The homogeneity test

   The guidelines for decision making are as follows:
   - H0: the data is homogeneous (p-value or Sig. > 0,05)
   - H1: inhomogeneous Data (p-value or Sig. < 0,05)

If the value of significance or Sig. > 0.05, then the variance of two or more population groups are considered equal (homogeneous), so H0 is accepted and H1 is rejected. Otherwise, if Sig. < 0.05, then H0 is rejected and H1 is accepted. Here are the variance homogeneity data for %MC:

Table 08. Output %MC for test homogeneous

Levene Statistic	df1	df2	Sig.
2.603	3	12	0.100

The interpretation of the table above shows that the Levene Statistic reflects a statistical value, where df1 is the degree of freedom for the numerator, df2 is the degree of freedom for the denominator, and p-value or Sig. is the probability value. Based on the table, it can be concluded that the variance between the experiments is the same (homogeneous).

Therefore, it can be concluded that the increase is quite significant. Photos of bioarang briquette products optimization results are shown in Figure 5.

Figure 5. photos of bioarang briquettes optimization results

C. *Check* Stage

7. Step 7: Evaluation of results

- **Cost Analysis Stage**

According to M Rosita et al. (2018) after identifying recycling alternatives that can be processed into briquettes, the next step is to conduct a cost analysis. This cost analysis is obtained from a series of waste carbon recycling processes. This cost breakdown is an analysis of business feasibility in terms of operations. The following table details the fees shown below :

Table 09. Recycling Project Cost Planning

Parameter	bioarang briquettes
Assumption	
Average market price (export&local)	Rp 20,634.62
Production	150 kg/day
Land rent (400m2) / month	Rp -
Equipment Investment	
Counting machine (50 kg / hour)	Rp 4,604,333.33
Printing machine (50 kg/hour)	Rp 5,439,166.67
Molen/mixer (50 kg)	Rp 4,523,600.00
Shovel 2 pieces	Rp 150,000.00
Scales (10 kg)	Rp 310,399.80
Weighing scale (150 kg)	moving assets
Bucket 4 pieces	Rp 250,000.00
Drying place	company land
ATK equipment	Rp 250,000.00

SUM	**Rp 15,527,499.80**
land lease	company land
Waste Carbon (Rp. 12,325 X150 kg x 26 days)	Rp 48,457,500.00
Tapioca (Rp.7,775 x 37.5 Kg x 26 days)	Rp 7,580,625.00
The Land (Rp. 823.08 x 150 Kg x 26 days)	Rp -
Employee salary (4 Person X Rp. 2.806.955,-)	Rp 11,227,820.00
Vehicles	Rp 4,250,000.00
Cost of electricity, water, telephone/month	Rp 1,200,000.00
Depreciation expense	Rp 3,005,499.96
Overhead costs	Rp 2,329,124.97
SUM	**Rp 78,050,569.93**
Cost Per Kg	**Rp 20,012.97**
Monthly income	
price x 150 Kg x 26	Rp 80,475,018.00
Net Income Per Month	
Revenue-cost of production	Rp 2,424,448.07
Fixed Costs	**Rp 9,584,624.93**
Non-fixed costs	**Rp 68,465,945.00**

(Source: processed by the author, 2024)

All variations of costs and techniques used serve as a comparison to the results of the value engineering. Recycling project recommendation stage is obtained by calculating the feasibility of the NPV (Net Present Value), BEP (Break Even Point) and ROI (Return of investment).

a. NPV (Net Present Value) according Yusniati et al. (2021), namely a business is said to be feasible if the NPV (Net Present Value) value is greater than the project cost or if the NPV minus the project cost is greater than zero. Calculation of NPV involves several steps, namely:
   - Determine future cash flows by identifying all cash inflows and outflows related to future investments or projects.
   - Set an appropriate discount rate to reflect the time value of money. This discount rate can be based on the cost of capital or the expected rate of return. In this study, a discount rate of 10% for 5 years was selected.
   - Calculate the present value of each cash flow by discounting each future cash flow using the formula:
     Present value = Cash Flow / (1+r)^t

     Where:
     - cash flow is cash flow in a given year (t),
     - r is the discount rate,
     - t is the year the cash flow was received or issued.
   - Summing the present value of all cash flows: once all future cash flows have been discounted, add up all those present values to obtain the NPV.
   - flows: once all future cash flows have been discounted, add up all those present values to obtain the NPV.

$$\text{NPV} = \sum_{t=0}^{n} \frac{\text{Arus Kas}_t}{(1+r)^t}$$

   Where :

   If t = 0, usually the cash flow is the initial investment issued.

b. BEP (Break Even Point)
   Richard M. Lynch in his book Accounting Management Planning and Control defines a Break Even Point (BEP) as "the volume level at which total cost equals total revenue, so profit is zero."From this definition, the Break Even Point can be interpreted as a level of sales where the total cost is equal to the total receipts from sales, so the profit is zero (E Jubaedah, 2020). In the BEP analysis, if the BEP value is lower than the selling price, the business is considered feasible to run. However, if the selling price is lower than the BEP, then the business is declared unfit to run.

- BEP formula in units :

$$BEP = \frac{\text{total fixed costs}}{\text{sale price per unit - variable cost per unit}}$$

c. ROI (Return of investment)
Return on Investment (ROI) is a ratio used to assess the efficiency or profitability of an investment. ROI is calculated by comparing the profits earned from the investment with the investment costs that have been incurred.
ROI formula:
ROI = (Net Profit / initial investment) x 100%

Table 10. Feasibility analysis of recycling project

Parameter	**Bioarang Briquette Recycling**	
	Per Month	**Per Year**
Sales Results	Rp 80,475,018.00	Rp 965,700,216.00
Initial investment	Rp 15,527,499.80	
Operational Cost	Rp 78,050,569.93	Rp 936,606,839.16
Laba	Rp 2,424,448.07 3.11%	Rp 29,093,376.84
NPV	Rp 110,286,788.00	
BEP	Rp 770,740,120.01	
ROI	**15.6%**	

(Source: processed by the author, 2024)

Based on the calculations of the above analysis, the following results were obtained:
- The NPV value is greater than the cost of the project, so the effort is considered feasible.
- The BEP value indicates that the selling price is greater than the BEP, so the business is declared feasible to run.
- Profit for recycling reached 3.11%, which is slightly higher than the interest on bank deposits (2-3%) plus business risk of 5%, so this business is feasible to run.

D. *Action* Stage

8. Step 8: Standardization and future plans

Further planning to get maximum results by implementing recycling projects. The problem solving plan is shown in the table 11 :

Table 11. Further planning

No	**Solusi**	**Rencana *Continous Improvement* Selanjutnya**
1	Minimize activated carbon (Reduce)	Multistage decolorization; find the cause of slow filter speed
2	Biochar growing media (Reuse)	Re-evaluate biochar quality requirements, growth on other crops
3	Biochar Briquettes (Recycle)	Look for alternative adhesives and pressing/printing machines to reduce costs

(Source: processed by the author, 2024)

IV. CONCLUSION

The conclusion that can be drawn from this study is that carbon waste can be recycled into bioarang briquettes. The characteristics of the briquettes meet the quality standards of SNI 01-6235-2000, where a lower moisture content (%MC) is considered better (small-the-better). Bioarang briquette optimization design using dry carbon waste; [adhesive] 25%; with pressure for 2 minutes. Engineering results show that bioarang (recycled) briquette products have a weight of 233.33 with an added value of 3.11% (Rp. 29,093,376.84 per year from a total of 150 kg of briquettes per day), NPV value exceeds project cost (+) of Rp 110,286,788,00, BEP value of Rp 770,740,120. 01, and ROI of 15.6%.

These findings indicate the implications or impacts of :

1. Identification of key findings: the study shows that carbon waste treatment strategies with recycling approaches are effective in increasing added value for the food additive industry.

2. Evaluation of the relevance of the findings: the findings are relevant for the food additive industry and small and medium industries, providing environmentally friendly business opportunities in accordance with SNI standards.
3. Impact Analysis:
   - Direct impact: changes in procedures, production processes, Department additions, and new regulations.
   - Indirect impacts: changes in regulations, policies, and steps toward a green industry.
4. Economic considerations: evaluation of economic impacts related to production costs, market prices, and profitability, with reference to the feasibility analysis Table.
5. SWOT analysis:
   - Strengths: reduced environmental impact, resource efficiency, improved corporate image, and cost reduction.
   - Weaknesses: initial implementation costs, lack of awareness, technological limitations, and logistical problems.
   - Opportunities: policy support, increased consumer awareness, technological innovation, and collaboration opportunities. Threats: changes in regulation, fluctuations in market prices, competition, and resistance to change.

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