Effect of Temperature on Moisture Content in Kernel (Palm Core) in Seed Silo by Complete Random Design Method (RAL) in Kernel Crushing Plant Unit of PT. Smart Tbk, Belawan

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ABSTRACT

The moisture content in palm kernels is one of the crucial factors influencing the quality and productivity of palm oil production. This research aims to analyze the effect of temperature on the moisture content in palm kernels at the Seed Silo in the Kernel Crushing Plant Unit of PT. Smart Tbk, Belawan, using the Complete Randomized Design (CRD) method and Simple Linear Regression. The kernels were collected from several plots of oil palm plantations spread across certain areas. In the process, it is essential to understand how temperature affects the moisture content in the kernels. The study was conducted with four repetitions for each experiment to determine the moisture content analysis data of the kernels in the Seed Silo. The results of the moisture content reduction calculations showed an optimum temperature of 100°C with the lowest moisture content of 6.26%. Based on the Complete Randomized Design (CRD) method, the results showed that the F-calculated value of 3.12 was greater than the F-table value of 2.95, meaning that H0 was rejected (temperature does not affect moisture content) and H1 was accepted (temperature affects moisture content). It can be concluded that the experiments at each given temperature significantly affected the resulting moisture content. Then, using the Simple Linear Regression method, a correlation coefficient value of -1.00 was obtained, indicating a perfect negative correlation between temperature (X) and moisture content (Y). The coefficient value indicates the strength of the relationship between variables X and Y. Simple linear regression shows that the higher the temperature, the lower the moisture content in the palm kernels. The practical implications can include recommendations for optimal temperature settings in the handling and processing of palm kernels to improve the quality and productivity of the production output.

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1. INTRODUCTION

PT. Smart Tbk, Belawan has a kernel crushing plant (KCP) with a production capacity of 700 tons/day which is one of the factories that produces crude palm kernel oil (CPKO) or palm kernel oil and produces palm kernel expeller (PKE) by-products.

The palm kernel processing process at PT. Smart Tbk, Belawan kernel crushing plant unit is carried out through weighing stations, palm kernel receipt (intake station), palm kernel storage (seed silo), pressing, meal storage (flat silo). In the Kernel Crushing Plant Unit of PT. Smart Tbk, Belawan, the kernel quality standard (palm kernel) has been set with a moisture content of 6-7%. However, challenges arise when companies experience cases of high moisture content, even reaching 10%.

This phenomenon raises concerns about the consistency of product quality and the efficiency of the production process, so that it exceeds the standard limit set by the company. As a result, the kernel (palm kernel) experiences fungal growth, the oil yield obtained becomes small due to the high moisture content in the kernel (palm kernel). Therefore, the temperature in the seed silo needs to be considered so that the kernels produced can meet the standards with good quality as expected by the company.

The cause of the high moisture content in the kernel (palm kernel) is the shipping process that involves ships from outside the province and also uses trucks. This long-distance transportation often causes the kernel (palm kernel) to absorb moisture during the trip, especially if it is the rainy season and the packaging and shipping are not well controlled. Under these conditions, palm kernels are susceptible to unwanted increases in moisture content.

As a solution to this problem, the company has implemented a heating method with a steam heater. Heating is an effective way to reduce the moisture content in the kernel (palm kernel) before entering the next stage of processing. However, the success of this heating is highly dependent on proper temperature regulation.

The existing Seed Silo at PT. Smart Tbk, Belawan has 7 units. Each unit contains 1000 tons of kernels. From the silo, there is one that is used as a steam heater, the filling in the silo is not filled up to 1000 tons, only 200 tons of kernels (palm kernels) are filled because if filled to a full 1000 tons, the withdrawal will not be able to be pulled out, heating will occur on the left and right continuously, it will result in unwanted things, namely the kernel burning. The working principle of the seed silo at PT. Smart Tbk, Belawan is by using hot steam through a steam heater that is blown by a blower from the bottom to the top on the seed silo. The use of the steam heater is regulated through the header (the required steam dividing pipe) and then from the header the steam pipe is opened which enters the heater pipe with a temperature that is maintained with the provision that it should not exceed 100°C because it is feared that the kernel can burn and the heating time with the steam heater used for 4 hours has a capacity of 200 tons. With continuous heating, it is hoped that it will reduce the moisture content to 6-7% in PT. Smart Tbk, Belawan. Thus, companies can develop guidelines or practical guidelines in regulating the heating temperature with a steam heater to match the desired moisture content standards.

In order to optimize the heating process with a steam heater, a deeper understanding of the effect of temperature on moisture content in the kernel (palm kernel) is needed. Therefore, this study aims to evaluate how temperature variations affect the moisture content in the kernels in the seed silo. In this study, the researcher used a heating method using the steam heater method to determine the moisture content.

2. METHOD

The primary data in this study are temperature, tools and materials, and sample weight. The secondary data used is existing production data. After the necessary data is considered sufficient, the next step is to process the data, namely:

a. The first step carried out in data processing is to determine the initial temperature obtained based on the determination from the company, namely at a temperature of 65°C - 100°C.
b. The second step is to weigh the initial weight of the sample (kernel) based on the determination of the sample used, which is 10 grams.
c. The third step is to weigh the final weight after dissteaming and put it in a desiccant for cooling.
d. Calculating the % decrease in moisture content
e. Testing the results of the calculation of moisture content reduction by the Complete Random Design (RAL) and Simple Linear Regression methods.

The following is a block diagram of data processing steps from research conducted at PT. Smart Tbk, Belawan.

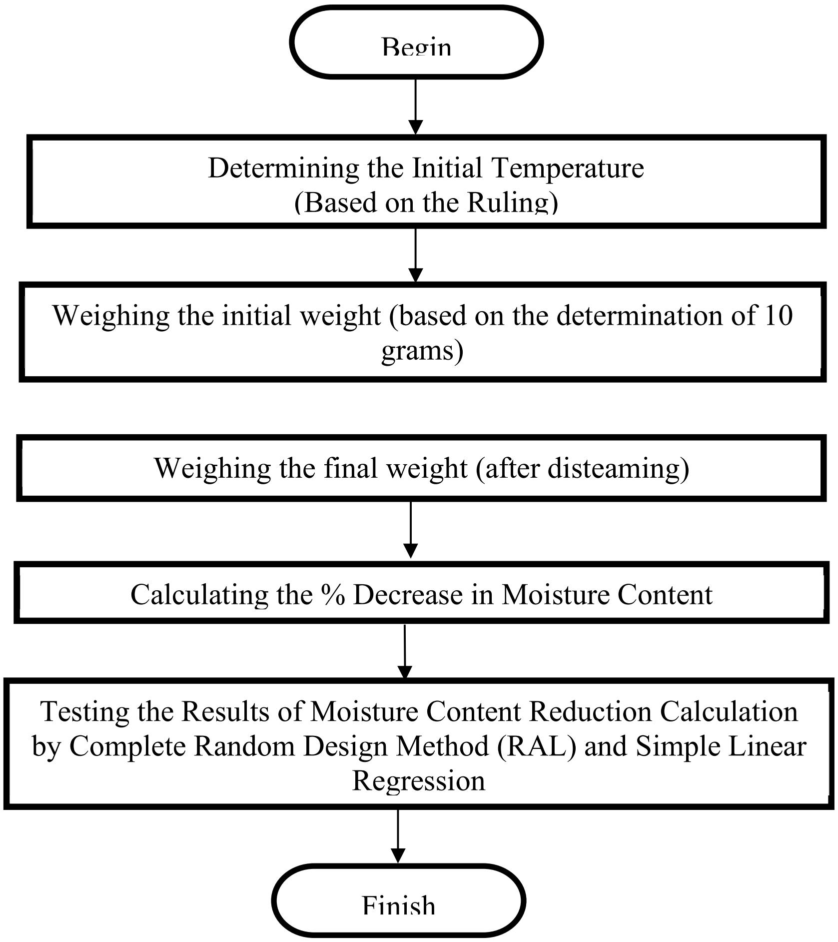

Figure 1. Data Processing Steps

Data collection includes data including temperature data (initial temperature), tools and materials, and the initial weight of the sample.

3. RESULTS AND DISCUSSION

The following is a table of water content analysis data on the kernel with four repetitions in each experiment. The following is the data from the analysis of the moisture content of palm kernels in seed silos, namely:

Table 1. Experimental Data 1 for Moisture Content

No	*Steam Heater* Temperature (°C)	Weight of Empty Porcelain Cups (Gram)	Porcelain Cup Weight + Cup Before Dissteam (grams)	Sample Weight Before Disteam (grams)	Porcelain Cup Weight + Cups After Dissteam (Gram)	Sample Weight After Disteam (Gram)
1	65	52,2222	62,4542	10,2320	61,4312	9,2090
2	70	52,1993	62,4107	10,2114	61,4393	9,2400
3	75	52,0994	62,3104	10,2110	61,3544	9,2550
4	80	51,8854	62,0625	10,1771	61,1566	9,2712
5	85	50,8721	61,0277	10,1556	60,1661	9,2940
6	90	50,7162	60,8650	10,1489	60,1143	9,3981
7	95	50,5087	60,6510	10,1423	59,9322	9,4235
8	100	50,4563	60,5627	10,1064	59,9543	9,4980

Tabel 2. Experimental Data 2 for Moisture Content

No	*Steam Heater* Temperature (°C)	Weight of Empty Porcelain Cups (Gram)	Porcelain Cup Weight + Cup Before Dissteam (grams)	Sample Weight Before Disteam (grams)	Porcelain Cup Weight + Cups After Dissteam (Gram)	Sample Weight After Disteam (Gram)
1	65	51,1122	61,3338	10,2216	60,3072	9,1950
2	70	51,0848	61,2908	10,2060	60,3125	9,2277
3	75	50,8954	61,0800	10,1846	60,1243	9,2289
4	80	50,8656	61,0162	10,1506	60,1961	9,3305
5	85	50,8415	60,9920	10,1506	60,1909	9,3494
6	90	50,6725	60,8174	10,1448	60,0419	9,3694
7	95	50,5894	60,7130	10,1236	60,0444	9,4550
8	100	50,4764	60,5931	10,1167	59,9614	9,4850

Tabel 3. Experimental Data 3 for Moisture Content

No	*Steam Heater* Temperature (°C)	Weight of Empty Porcelain Cups (Gram)	Porcelain Cup Weight + Cup Before Dissteam (grams)	Sample Weight Before Disteam (grams)	Porcelain Cup Weight + Cups After Dissteam (Gram)	Sample Weight After Disteam (Gram)
1	65	52,3262	62,5571	10,2309	61,5012	9,1750
2	70	52,2401	62,4371	10,1970	61,4326	9,1925
3	75	51,9889	62,1683	10,1793	61,1848	9,1959
4	80	50,7003	60,8307	10,1304	59,9160	9,2157
5	85	50,4706	60,5949	10,1243	59,7856	9,3150
6	90	50,3418	60,4522	10,1105	59,6668	9,3250
7	95	50,2159	60,3264	10,1105	59,5659	9,3500
8	100	50,1330	60,2396	10,1066	59,6287	9,4957

Tabel 4. Experimental Data 4 for Moisture Content

No	*Steam Heater* Temperature (°C)	Weight of Empty Porcelain Cups (Gram)	Porcelain Cup Weight + Cup Before Dissteam (grams)	Sample Weight Before Disteam (grams)	Porcelain Cup Weight + Cups After Dissteam (Gram)	Sample Weight After Disteam (Gram)
1	65	51,5585	61,7894	10,2309	60,7485	9,1900
2	70	51,4588	61,6510	10,1922	60,6588	9,2000
3	75	51,1383	61,3274	10,1891	60,3518	9,2135
4	80	50,6683	60,8138	10,1455	59,9194	9,2511
5	85	50,2745	60,4198	10,1453	59,5547	9,2802
6	90	50,1952	60,3194	10,1243	59,4622	9,2670
7	95	50,1854	60,2959	10,1105	59,4979	9,3125
8	100	50,1774	60,2809	10,1035	59,5989	9,4215

Table 5. Kernel Moisture Content Calculation (Experiment 1)

Drying Conditions at Temperature	**Decrease in moisture content**
65 °C	10,00 %
70 °C	9,51 %
75 °C	9,36 %
80 °C	8,90 %
85 °C	8,48 %
90 °C	7,40 %
95 °C	7,09 %
100 °C	6,02 %

Table 6. Calculation of Kernel Moisture Content (Experiment 2)

Drying Conditions at Temperature	Decrease in moisture content
65 °C	10,04 %
70 °C	9,59 %
75 °C	9,38 %
80 °C	8,08 %
85 °C	7,89 %
90 °C	7,64 %
95 °C	6,60 %
100 °C	6,24 %

Table 7. Calculation of Kernel Moisture Content (Experiment 3)

Drying Conditions at Temperature	Decrease in moisture content
65 °C	10,32 %
70 °C	9,85 %
75 °C	9,66 %
80 °C	9,03 %
85 °C	7,99 %
90 °C	7,77 %
95 °C	7,52 %
100 °C	6,05 %

Table 8. Calculation of Kernel Moisture Content (Experiment 4)

Drying Conditions at Temperature	Decrease in moisture content
65 °C	10,17 %
70 °C	9,73 %
75 °C	9,57 %
80 °C	8,82 %
85 °C	8,53 %
90 °C	8,47 %
95 °C	7,89 %
100 °C	6,75 %

Based on the calculation from the kernel data obtained, the results are as follows:

Table 9. Results of Moisture Content Analysis in Kernels

Drying Conditions (°C)	Decrease in Experimental Moisture Content (%)				Average
	1	2	3	4	
65	10,00	10,04	10,32	10,17	10,13
70	9,51	9,59	9,85	9,73	9,67
75	9,36	9,38	9,66	9,57	9,49
80	8,90	8,08	9,03	8,82	8,71
85	8,48	7,89	8,53	8,53	8,36
90	7,40	7,64	7,77	8,47	7,82
95	7,09	6,60	7,52	7,89	7,28
100	6,02	6,24	6,05	6,75	6,26

Here is the average % of moisture content in the kernels from each experiment based on each temperature:

Table 10. Average Results of Moisture Content Analysis in Kernels

Drying Conditions (°C)	Average Moisture Content (%)
65	10,13
70	9,67
75	9,49
80	8,71
85	8,36
90	7,82
95	7,28
100	6,26

The following is a tabulating of the treatment and decomposition data between temperature and moisture content produced as follows:

Table 11. Tabulation of Treatment Data and Repeatability Between Temperature and Moisture Content

No	Deuteronomy	Treatment				Total
		A	B	C	D	
1	65	10,00	10,04	10,32	10,17	
2	70	9,51	9,59	9,85	9,73	
3	75	9,36	9,38	9,66	9,57	
4	80	8,90	8,08	9,03	8,82	
5	85	8,48	7,89	8,53	8,53	
6	90	7,40	7,64	7,77	8,47	
7	95	7,09	6,60	7,52	7,89	
8	100	6,02	6,24	6,04	6,75	
Total		66,760	65,460	68,720	69,930	270,870
Rata-rata		8,345	8,183	8,590	8,741	33,859

The following is a table of variance analysis, namely:

Table 12. Variance Analysis

Source Diversity	Degree Free	Sum Squares (JK)	Squares Middle (KT)	F-Calculate	F-Tabel 0,05
Treatment	t-1 4-1=3	JKP 48,20	KTP =JKP/(t-1) = 48,20/3 =16,07	F =KTP/KTG =16,07/5,15 3,12	2,95
Error	t(r-1) 4(8-1) 28	JKG 2,94	KTG =JKG/t(r-1) =2,94/4(8-1) =5,15		
Total	tr-1 4.8-1 31	JKT 51,14			

Based on the above calculations, the following hypothesis testing is obtained:
F-calculate = 3.12
F-table = 2.95

So F-count 3.12 > F-table 2.95 was obtained, which means that H0 is rejected (temperature has no effect on moisture content) and H1 is accepted (temperature affects moisture content). It can be concluded that the treatment given to the experimental units has a real influence on the observed response or the experiment of each temperature given has a real effect on the moisture content produced. The use of correlation test is to find the relationship between the free variable (X), namely temperature, and the variable (Y), namely the moisture content in the palm kernel.

Table 13. Interpretation of Correlation Coefficients

Correlation Coefficient (Positive or Negative)	Interpretation of Correlation Coefficients
0,00	No Correlation
0,01-0,20	Very Weak Correlation
0,21-0,40	Weak Correlation
0,41-0,70	Medium Correlation
0,71-0,99	High Correlation
1,00	Perfect Correlation

Table 14. Calculation of Correlation of Free Variable X (Temperature) and Bound Variable Y (Moisture Content)

No	X	Y	X^2	Y^2	X.Y
1	65	10,13	4225	102,6169	658,4500
2	70	9,67	4900	93,5089	676,9000
3	75	9,49	5625	90,0601	711,7500
4	80	8,71	6400	75,8641	696,8000
5	85	8,36	7225	69,8896	710,6000
6	90	7,82	8100	61,1524	703,8000
7	95	7,28	9025	52,9984	691,6000
8	100	6,26	10000	39,1876	626,0000
Total	**660**	**67,72**	**55500**	**585,2780**	**5475,9000**

The result of the calculation of the correlation coefficient between temperature and moisture content is -1.00 which means that both variables have a perfect correlation level.

Based on the results of the calculations, a graph of the relationship between temperature and moisture content in the palm kernel can be seen in the following figure:

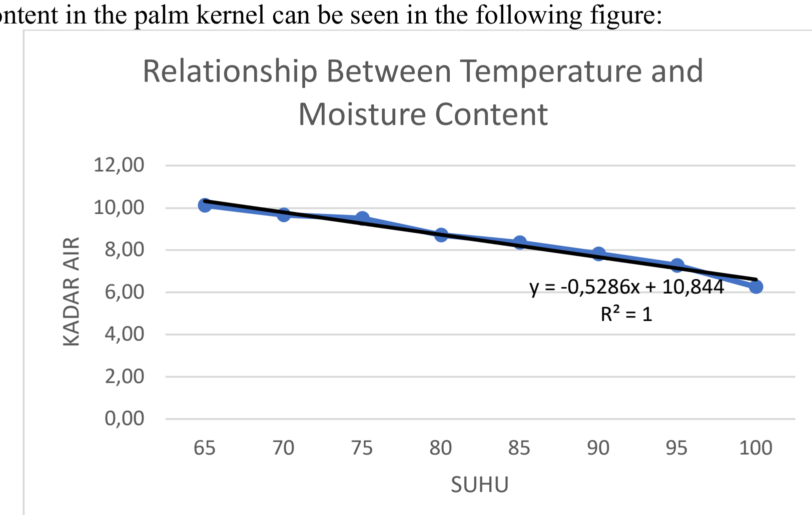

Figure 2. Relationship Between Temperature and Moisture Content

Analysis of Moisture Content in Kernels

Table 15. Results of Moisture Content Analysis in Kernels

Drying Conditions (°C)	Average Moisture Content (%)
65	10,13
70	9,67

75	9,49
80	8,71
85	8,36
90	7,82
95	7,28
100	6,26

From the results of the analysis conducted with four experiments, the optimum temperature at 100°C with the lowest moisture content in the palm kernel was 6.26% during the drying process of the palm kernel in the seed silo. This shows that drying at this temperature is very effective in reducing the water content in the palm kernel. Low moisture content is important to prevent the growth of microorganisms and maintain the quality and shelf life of palm kernels. Knowing that a temperature of 100°C is the most effective, the treatment unit can set the drying system to operate at this temperature, thus saving energy that may be wasted at less than optimal temperatures. The discovery of this optimum temperature helps in setting operational standards for the palm kernel drying process in seed silos.

Complete Random Design Analysis (RAL)

Based on the calculation carried out by the complete random design method (RAL), F-count 3.12 > F-table 2.95 were obtained, which means that H0 is rejected (temperature has no effect on moisture content) and H1 is accepted (temperature has an effect on moisture content). It can be concluded that the treatment given to the experimental units has a real influence on the observed response or the experiment of each temperature given has a real effect on the moisture content produced. Where the higher the temperature used, the lower the moisture content produced. The drying temperature should not be less or more than the set. If the temperature is low, the moisture content of the palm kernel is still high, so it will help accelerate the growth of fungi in the palm kernel. On the other hand, if the temperature is too high, there will be burnt in the palm kernel because it damages the palm kernel and the quality obtained is not good, so the oil produced from *the kernel* (palm kernel) will be less.

Simple Linear Regression Analysis

From the correlation analysis carried out, a value is obtained called the correlation coefficient. The correlation coefficient can be positive or negative and the correlation coefficient value ranges from -1.00 to +1.00. Negative correlation is shown by a correlation coefficient with a negative value and vice versa, a positive correlation is shown by a correlation coefficient with a positive value. A correlation coefficient value of -1.00 indicates that there is a perfect negative correlation between drying temperature (X) and moisture content (Y). The value of the correlation coefficient shows the close relationship between the X variable and the opposite Y variable, this means that the more the value of the X variable (temperature) increases, the value of the Y variable (moisture content) will decrease.

4. CONCLUSION

From the analysis of the decrease in moisture content, it can be concluded that the optimum temperature is obtained at 100°C with the lowest moisture content in palm kernel being 6.26%. Based on the analysis that has been carried out using the Complete Random Design (RAL) method, F-count 3.12 > F-table 2.95 was obtained, which means that H0 was rejected (temperature had no effect on moisture content) and H1 was accepted (temperature had an effect on moisture content). It can be concluded that the treatment given to the experimental units has a real influence on the observed response or the experiment of each temperature given has a real effect on the moisture content produced. The effect of temperature on the moisture content of the palm kernel in the seed silo is that the higher the temperature used, the lower the moisture content produced. The drying temperature should not be less or more than the set. If the temperature is low, the moisture content of the palm kernel is still high so that it will help accelerate the growth of fungi in the palm kernel. On the other hand, if the temperature is too high, there will be burnt in the palm kernel. Based on the linear regression method carried out, the correlation coefficient value was obtained between -1.00 to +1.00. Negative correlation is shown by a correlation coefficient with a negative value and vice versa, a positive correlation is shown by a correlation coefficient with a positive value. A correlation coefficient value of -1.00 indicates that there is a perfect negative correlation between drying temperature (X) and moisture content (Y). The value of the correlation coefficient shows the close relationship between the X variable and the opposite Y variable, this means that the more the value of the X variable (temperature) increases, the value of the Y variable (moisture content) will decrease.

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