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The Optimization of Additional carol on the Biodegradable Foam from Corn Husk

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Abstract *– Biofoam is an environmentally friendly food packaging. Biofoam made from starch and fiber raw materials have low tensile strength. Additional glycerol can increase elasticity e internal hydrogen bonds which can reduce the distance between molecules. The purpose of this study was to determine the effect of biofoam from sago starch and corn husk cellulose with a plasticizer (glycerol) using the roasting process. This research uses factorial design 2^3, with variations in glycerol concentrations of 3% and 7%, variations in roasting temperature of 115°C and 135 °C ,and roasting times of 50 minutes and 70 minutes. The optimum condition of biofoam was found at a glycerol concentration of 7% with a tensile strength value of 0,42 MPa, water absorption value of 35,07%, and biodegradability value of 27.76% within 14 days.Variations in operating conditional affects the visual and texture of the biofoam produced under condition of 135°C for 5o minutes. The gelatinization temperature of sago starch is 73 – 79℃. This study using temperature variations of 115°C and 135°C. And the result of the morphological analysis showed that biofoam with high temperaure, has a high-water absorption because if it has passed the starch gelatinization temperature, the starch will form a paste and dissolve in water*.

Keywords: biodegradable foam; corn skin; glycerol
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INTRODUCTION

Styrofoam is a packaging food that has a bad impact on time future, and the rubbish of styrofoam is difficult to decompose in the environment. Based on the impact negative of styrofoam, the need did study more and continue to create ingredients alternative replacement styrofoam. Where it has the same function as styrofoam and is friendly to the environment. Scientists and experts try to make ingredients as alternative replacements to styrofoam. One of them is biodegradable foam or biofoam (Sanhawong *et al.*, 2017).

Biodegradable foam is packer food made from starch easy unraveling and friendly to the environment. Biodegradable foam is a food packer economical and the ingredient easy to find. Even though, biodegradable foam with ingredients raw starch, have a low water absorption and low flexibility (Nansu *et al.*, 2021).

The problem of biodegradable foam about of low flexibility, addition glycerol can increase flexibility. Glycerol is a plasticizer that can increase elasticity, cause glycerol can reduce the bond internal hydrogen so which increases intermolecular distance. The value of tensile strength will increase while the concentration of glycerol high (Mustapha and Wan, 2022).

Corn husk own content cellulose by 42%. With content high cellulose in the skin corn, yes utilized more maximum in making biodegradable foam (Kumar, 2014). This study is focuse of the effect biodegradable foam from flour of sago and cellulose corn husk with plasticizer (glycerol) using

the baking process. The effect of glycerol concentration and condition process of biofoam.

METHODOLOGY

Materials and Tools

Materials used in the preparation of fiber corn husk are corn husk, aquadest, and 10% NaOH, as well as materials used in making biodegradable foam are fiber corn husk, starch sago, magnesium stearate 5%, PVA 10%, and aquades. Corn husk can be obtained in the area of Bandungan, Semarang, and Central Java and materials supporter other originated from Laboratory Diponegoro University.

In this research, there are fixed variables and independent variables. The independent variable used in this research is concentration of glycerol and conditions of operation (temperature and time). Independent Variable used in this research, with use factorial design method where there are 2 variables independent and each variable is taken 2 points. More clarity could see in Table 1.

Table 1. Variations Independent Variable with the Factorial Design Method

Run	Glycerol (ml)	Time (minutes)	Temperature (℃)
1	3	50	115
2	7	50	115
3	3	70	115
4	7	70	115
5	3	50	135
6	7	50	135
7	3	70	135
8	7	70	135

Method

Preparation of fiber corn husk

Leather fiber corn dry mashed use a blender and sieve pass 60 mesh. Take it corn husk weighed as much as 50 g and added 50 ml of distilled water with 5% NaOH. Then heated with water batch at 85 ℃ for 30 minutes. Next filtered and washed with water until the pH is neutral as well as dried in an oven at 105 ℃ for 60 minutes.

Making biofoam

Raw material in the form of starch sago, fiber corn husk, magnesium stearate, PVA, aquades, and glycerol (according to variables) are mixed with ingredients ratio dry and wet 60:40 in 100 ml. Next stirred with a mixer. Then input the ingredients into the oven with temperature and time according tovariation.

Water absorption test

Power analysis absorbs water against biodegradable foam based on the article (Liu *et al.*, 2019). Analysis of power water absorption with a sample cut size 3 x 5.5 cm and weighed as heavy early. Sample soaked for 1 minute, then removed and dried with tissue that works remove the water on the surface, then weighed return as a heavy end. Sample weight end and beginning compared, then done calculation with formula as following:

$$\text{Water (\%)} = \frac{\text{Wi}-\text{Wo}}{\text{Wo}} \text{x } 100\% \quad (1)$$

Biodegradation analysis

Biodegradation analysis of biodegradable foam based on the article (Machado, Benelli and Tessaro, 2020). Sample cut with size 3 x 5.5 cm ago input into the desiccator and weighed as heavy early. Sample buried in the box containing land with a height of 25 cm and done for 14 days. After 14 days, the sample was cleaned from the remainder clinging soil, then weighed as a heavy end and done calculation lost heavy with the formula:

$$\text{Lost weight (\%)} = \frac{\text{Wo}-\text{Wi}}{\text{Wo}} \text{ x } 100\% \quad (2)$$

Tensile strength analysis

Tensile strength analysis of biodegradable foam based on the article (Kaisangsri, Kerdchoechuen and Laohakunjit, 2012). Sample cut with size 13 mm x 57 mm with 7 mm thick. Test isdone with method placing the specimen in the hand test machine. Indicator extension (extensometer) is installed. measuring device strains transverse installed. Done measurement load and voltage. Speed testing is set by the required speed. Stress load curve noted other than that also note the value voltage and load moment separated.

$$\text{Tensile Strength} = \frac{F}{A} \quad (3)$$

RESULTS AND DISCUSSION

Result of biofoam with the method of the baking process made from raw starch sago, fiber skin corn, glycerol, magnesium stearate, PVA, and aquades shown in Table 2. Variables used that is concentration glycerol, time operation, and temperature operation.

Table 2. Results of Making Biodegradable Foam with Variation Concentration Glycerol and Condition Operation

Run	Concentration Glycerol (ml)	Time (minutes)	Temperature (ºC)
1	3	50	115
2	7	50	115
3	3	70	115
4	7	70	115
5	3	50	135
6	7	50	135
7	3	70	135
8	7	70	135

Table 3. shows that the effect major in this research is temperature operation with a mark of 35.47 with effect interaction in the form of concentration glycerol and time operation of 8.62.

Table 3. Calculation Results Main Effects and Effects Interaction on the Water Absorption Value of Biodegradable Foam.

Effect	Mark
C	10.77
t	19.60
T	35.47→ Main Effect
Ct	8.62→ Effect Interaction
CT	-2.23
tT	-6.84
CtT	-2.40

Tabel 4. Calculation Results in Main effects and Effects of Interaction on Biodegradable Foam. Biodegradation Value

Table 4 shows that the effect major in this research is concentration glycerol with a mark of -4.51 with effect interaction in the form of concentration glycerol and temperature operation of 1.71.

Table 5. Determination Variable Influential on Water Absorption of Biodegradable Foam

P(%)	Effect	Identity Effect
7.14285	-6.84	Tt
21.4285	-2.40	CtT
35.7142	-2.23	CT
50	8.62	Ct
64.2857	10.77	C
78.5714	19.60	t
92.8571	35.47	T

Table 6. Determination Variable Influential against Biodegradable Foam Biodegradation

P(%)	Effect	Identity Effect
7.14285	-18,80	T
21.4285	-7.92	t
35.7142	-4.51	C
50	-2.60	Ct
64.2857	0.80	tT
78.5714	1.36	CtT
92.8571	1.71	CT

Figure 1. displays a chart normal probability plot between P-value with effect obtained regression (R^2) of 0.913 with activating feature trendlines in Microsoft excel. This thing means that 91.3% of the total variety of models can be represented with equality regression. The equation that shows the correlation between mark power water absorption and research process parameters (temperature operation) is y = 1.9857x + 32,129. Then from that, on analysis power absorb water biodegradable foam could conclude that temperature operation is the most influential variable.

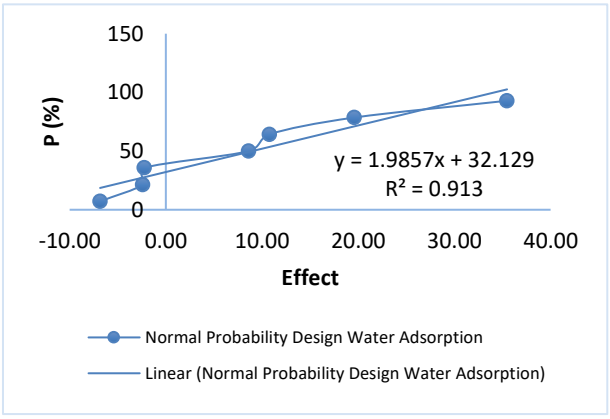

Figure 1. Chart Normal Probability Plot on Water Absorption of Biodegradable Foam

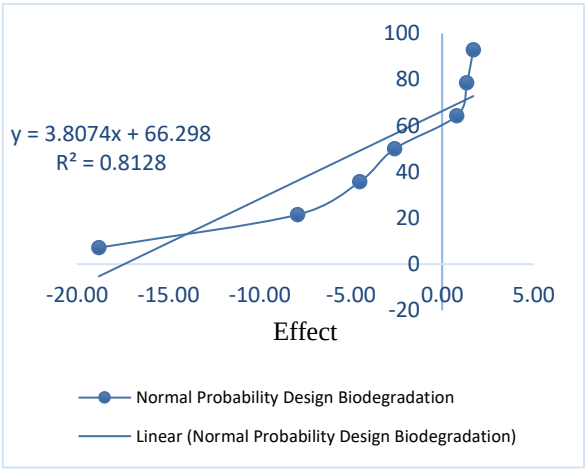

Figure 2. Graph of Normal Probability Plot on Biodegradable Foam

Figure 2. displays a chart normal probability plot between P-value with effect obtained regression (R^2) of 0.8128 with activating feature trendlines in Microsoft excel. This thing means that 81.2% of the total variety of models can be represented with equality regression. The equation that shows correlation Among mark biodegradation and concentration glycerol is y = 3.8074x + 66,298. Then from that, on analysis of degradation of biodegradable foam could conclude that the concentration of glycerol is the most influential variable.

Physical Analysis of Biodegradable Foam

Effect glycerol concentration with water absorption on biofoam

Water absorption power is the amount of water absorbed by the biodegradable foam after being dipped in water with variations of different time (Liu *et al.*, 2019). This analysis for shows that biodegradable foam submerged in water will experience damage in time certain. When biodegradable foam is submerged in water with a variation time certain, the water will diffuse to in ingredients of biodegradable foam.

Effect	Mark
T	-18,80
t	-7.92
C	-4.51→ Main Effect
Ct	-2.60
tT	0.80
CtT	1.36
CT	1.71→Effect Interaction

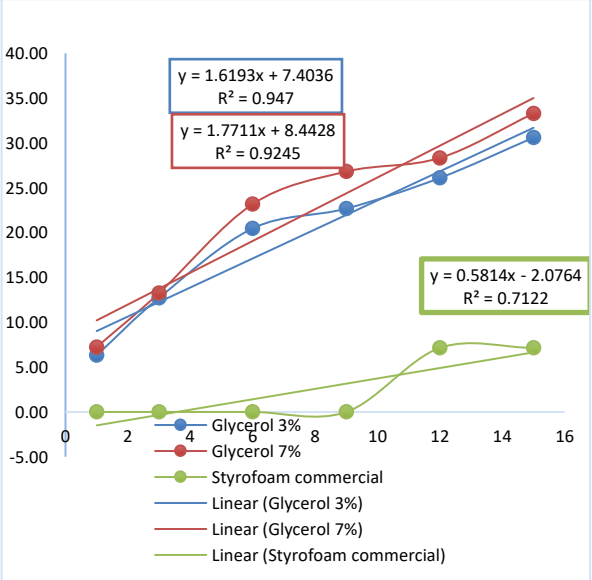

Figure 3. Graphics Connection Concentration Glycerol on Water Absorption of Biodegradable Foam

Based on Figure 3. water absorption increase along running time. Concentration glycerol is one influence addition power absorb on biodegradable foam. Glycerol own nature hygroscopic, with nature this make glycerol have power high water absorption, the more many glycerol added to biodegradable foam, then power absorb water on biodegradable foam will increase (Lee *et al.*, 2013). The result as theory, where power absorb water on biodegradable foam with glycerol concentration 7% more more than concentration glycerol 3%.

Biodegradable foam with glycerol concentration 3% into the water for 15 minutes, and the value absorb water by 34.49% which can be said more good than biodegradable foam with glycerol concentration 7% with power absorb water under the same conditions by 35.07%.

This research is also testing styrofoam commercially available on the market the value of absorb water during into water for 15 minutes by 7.14%. Intermediate result styrofoam commercial with biodegradable foam still very far away, because glycerol is hygroscopic, and make the product high absorb more water.

Influence condition operation on water absorption

Based on Figure 4. temperature and time drying could influence power absorb water. That thing due to the process biodegradable foam with method baking where details starch will thicken while trapped water will evaporate with fast, cause batter expand and fulfill mold (gelatinization). Warm-up time gelatinization could influence viscosity starch, where the longer the process so viscosity the morehigh. While at temperature gelatinization, if pass optimum temperature, then starch will form a paste (Arya Yudanto and Pudjihastuti, 2020).

Improvement temperature could increase solubility starch, granule heated starch with range temperature certain until reach temperature gelatinization will result in granule form a thick starch paste in the form of granule starch swollen like a gel elastic. Starch sago own temperature gelatinization 69.4–70.1°C (Kumar, 2014). This thing showing that manufacture of biodegradable foam based cooked starch exceed temperature gelatinization his tend increase power absorb water, where cooking time 70 minutes produce power absorb more water than 50 minutes of cooking, that is reached 36.13% for temperature 135 and 23.96% for temperature gelatinization 115.

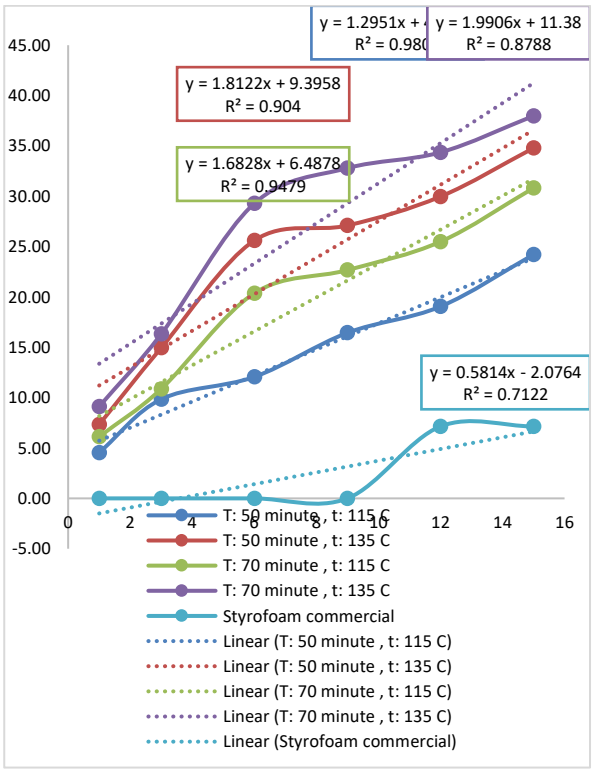

Figure 4. Graphics Connection Condition Operation on Water Absorption of Biodegradable Foam

In this research, variation determination printing process conditions biodegradable foam on the oven has an effect by significant. This thing proven in Table 2. which shows that effect main on value power absorb is temperature cooking with mark of 35.47%. Visible thing invisible eye is on the visual appearance of biodegradable foam generated with variation condition operation. In Table 7. displays visual appearance of the resulting biodegradable foam .

Table 7. Visual Appearance of Biodegradable Foam with Variation Condition Operation

Condition Operation		Visual Appearance of Biodegradable Foam	
T (℃)	t (Minutes)	Glycerol 3%	Glycerol 7%
115	50	white color dusty, texture soft, a little wet ,sticky with mould .	White color, texture soft, a little wet, sticky with mould .
115	70	white color flour, texture hard, regardless from mould .	white color flour, texture hard, regardless from mould.
135	50	white color dust, texture normal, regardless from mould .	Color white (slightly dark), texture normal, regardless from mould .
135	70	Color white (slightly dark), texture hard once, difficult miss from mould .	Color white (slightly dark), normal texture , detached from mould .

Biodegradable foam with best condition operation is at a temperature of 135℃ for 50 minutes with glycerol concentration 7%.

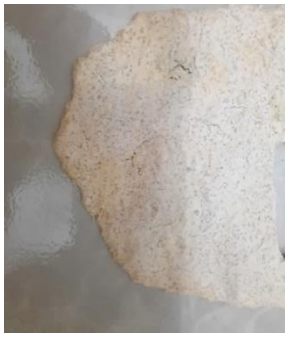

Figure 5. Display of the Produced Biodegradable Foam

Influence concentration glycerol and condition operation on the biodegradation of biofoam

Biodegradation analysis for now big samples that are decomposed by microorganisms in the land. This analysis with method immersion soil, where the resulting biofoam soaked in the land for 14 days and weighed every day for know lost the mass that happened consequence decomposed by microorganisms. Connection condition operation with percentage damage biofoam could seen in Figure 6. below.

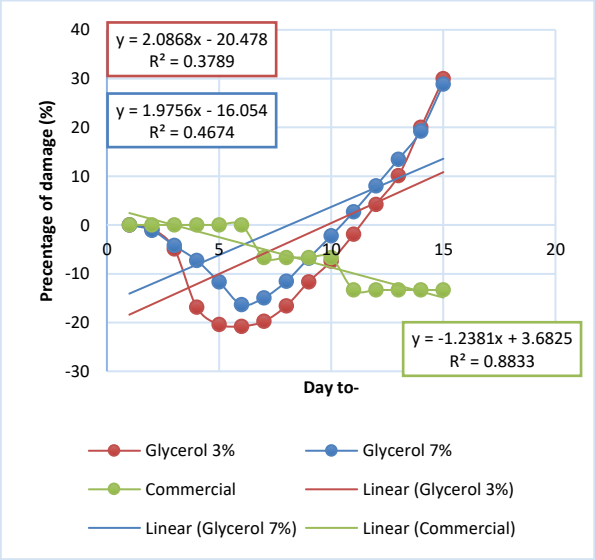

Figure 6. Graphics Connection Concentration Glycerol with Percentage Damage Biodegradable Foam

Glycerol consentration increase, make the value of biodegradation on biofoam will the more

height. This is because ability glycerol for tie humidity air, so mark biodegradation biofoam increase along with increase concentration glycerol (Lee *et al.*, 2013).

Based on the graph shown in Figure 6. shows that the more tall concentration glycerol added to biodegradable foam so the more low mark its biodegradation. Showed mark biodegradation with temperature and time same operation biofoam with concentration 7% more glycerol low of 27.76 compared to with concentration 3% glycerol.

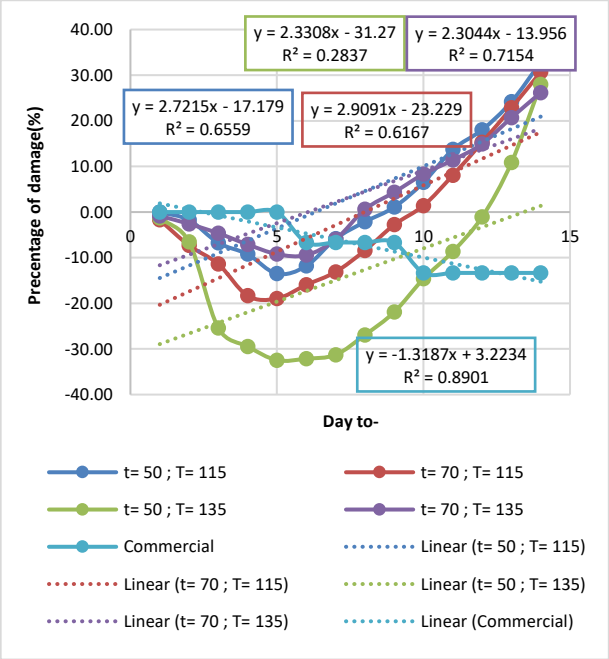

Figure 7. Graphics Connection Condition Operation (Temperature and Time) against Percentage Damage to Biodegradable Foam

Connection Among condition operation with biodegradation of biodegradable foam in this research could seen in Figure 7. which shows that the longer the time immersion biodegradable foam in land, percentage damage or lost mass will the more big. But in sample 6 biodegradable foam experience drop percentage damage reached -29.11% in 7 days first and start increase by day next until day 13 then showing positive presentation 6.94%. Addition percentage damage to biodegradable foam that reaches this negative value suspected because fluid effective microorganisms -4 (EM-4) added to in land before hoarding biodegradable foam and also contains bacteria photosynthetic (actinomycetes). Addition cellulose could influence percentage damage biodegradable foam in land, because cellulose is biofiller which causes biodegradable foam becomes easy unraveled in land and character organic, where in the manufacture biodegradable in this research use ingredients addition corn husk containing cellulose as much as 44% (Mehraj and Sistla, 2022). Based on Standard Data International ASTM 5336 shows that long time needed for styrofoam commercial degraded that is 60 days (Arya Yudanto and Pudjihastuti, 2020). addition, in study this is also done testing to styrofoam commercial with percentage damage by -13.33% for 14 days hoarding in land. On this research time degradation biodegradable foam for 14 days produce percentage damage of 10.98% which is the value of this will keep going increase with along running time until biodegradable foam could degraded fully in the land

Analysis Morphology to Biofoam

The result of biodegradable foam was also tested the mechanic. As for testing by mechanic is testing tensile strength. The most influential variable to tensile strength analyzed biodegradable foam through calculation effect main and effect interaction with quicker method is listed on Tables 8 and 9 below.

Table 8. Calculation Results Main Effects and Effects Interaction to the Tensile Strength of Biodegradable Foam

P(%)	Effect	Identity Effect
7.14285	-0.39	T
21.4285	-0.35	CtT
35.7142	-0.17	tT
50	-0.05	Ct
64.2857	0.29	CT
78.5714	0.31	C
92.8571	0.35	T

Table 9. Determination Variable Influential to the Tensile Strength of Biodegradable Foam

Effect	Mark
C	0.31
t	-0.39
T	0.35→ Main Effect
Ct	-0.05
CT	0.29→ Effect Interaction
tT	-0.17
CtT	-0.35

In Table 8. shows that effect major in research this is the temperature with mark of 0.35 with effect interaction in the form of concentration glycerol and temperature operation of 0.29.

Table 10. Observations of Tensile Strength of Biodegradable Foam

Sample	Condition Operation		Tensile Strength
	t (Minutes)	T (℃)	(Mpa)
1	50	115	0.2
2	50	115	0.13
3	70	115	0.07
4	70	115	0.15
5	50	135	0.17
6	50	135	0.42
7	70	135	0.13
8	70	135	0.18

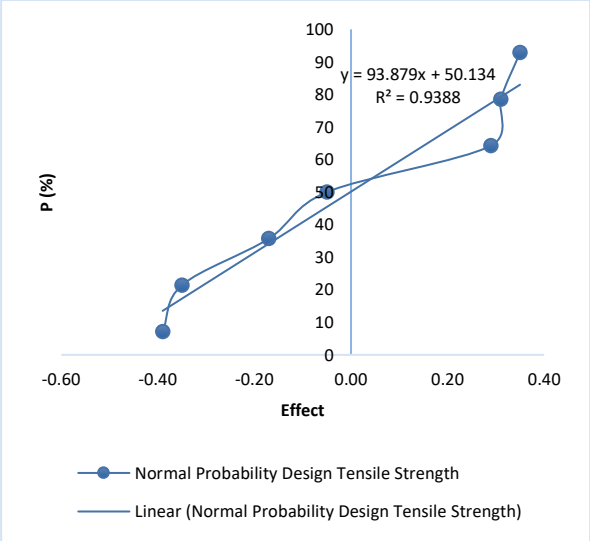

Figure 10. Garfik Normal Probability Plot to the Tensile Strength of Biodegradable Foam for Factorial Design 2 ^{3}

In Figure 10. showing chart normal probability plot Among P value with effect obtained regression (R^2) of 0.9388 with activate feature trendline in microsoft excel. This thing means 93.88% of the total variation of the model can be represented with equality regression. The equation that shows correlation Among mark power strong tensile strength and research process parameters (concentration glycerol and conditions operation) is y = 0.01x – 0.5014. Then from that is, operating temperature is the most influential variable to analysis power strong tensile biodegradable foam.

Effect concentration glycerol and condition operation to Tensile strength on biofoam

Product biodegradable foam produced with ingredients raw in the form of starch from flour sago and plasticizer in the form of glycerol tested nature the mechanic with do a strong test tensile strength.

Function glycerol as a plasticizer that can increase tensile strength on biodegradable foam (Choi and Han, 2001). Glycerol could increase elasticity, because ability in reduce bond internal hydrogen so that increase intermolecular distance (Mustapha and Wan, 2022). Tensile strength of biofoam increase along with increase concentration glycerol.

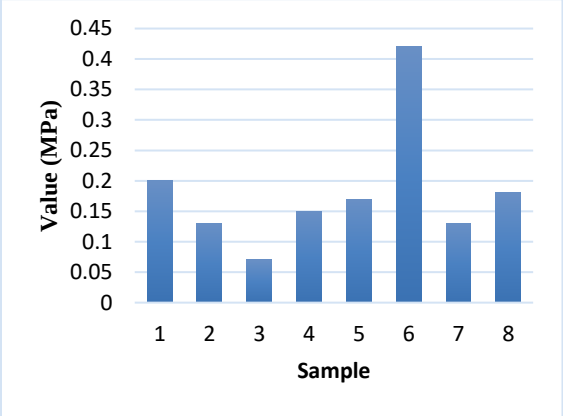

Figure 11. Graphics Connection Concentration Glycerol against Tensile Strength Biofoam

Analysis result tensile strength biodegradable foam in research this shown in Table 10. and Figure 11. where tensile strength highest generated by sample 6 with concentration 7% glycerol of 0.42 Mpa and the value of tensilne strength lowest by sample 3 with concentration 3% glycerol of 0.07 Mpa .

High temperature and the longer the time warm up tensile strength will the more high because complete the gelatinization process. When temperature too high and time too long tensile strength will down, because already reach the gelatinization process and occur decomposition. Based on Product Information Commercial data mention that styrofoam commercial own tensile strength of 0.1 Mpa (Arya Yudanto and Pudjihastuti, 2020).

Based on results study connection condition operation with tensile strength biodegradable foam shown in Figure 12. Where is the sample with high tensile strength with condition 135℃ operation for 50 minutes of 0.42 Mpa , and the value of lowest tensile strength on sample 3 with condition 115 operation for 70 minutes of 0.07 MPa . The biodegradable foam generated in this research the results have a tensile strength more than and fulfilling

standard tensile strength commercial except in sample 3 with mark strong tensile 0.07 Mpa .

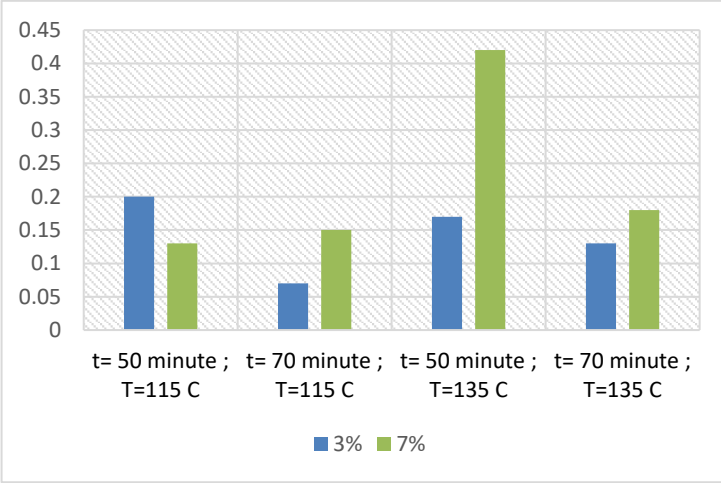

Figure 12. Graphics Connection Condition Operation to Tensile Strength (Mpa) Biodegradable Foam

CONCLUSION

Condition operation moment cooking could affect nature physical and mechanical from the resulting *biodegradable foam* . The optimum conditions produced in *biodegradable foam* are at a temperature of process 135℃ for 50 minutes with value water absorb 35.07%, value of tensile strength 0.42 Mpa and value of biodegradation is 10.997% for 14 days. This thing showing that making *biodegradable foam* based starch exceed temperature gelatinization his tend increase water absorb, the temperature gelatinization starch sago is 73.0 – 79.0.

Variation concentration glycerol in manufacture *biodegradable foam* with time 50 minutes cooking unfluential by significant to results power absorb water or tensile strength, however influential on the visual biodegradable *foam* produced. Seen with the more length of cooking process, color *biofoam* will the more dark and hard. Variation glycerol concentration, already in accordance with *biofoam* based on data from *Product Information Commercial* which states that *styrofoam* commercial own tensile strength of 0.1 Mpa , so that *biodegradable foam* generated in this research have tensile strength more, which is 0.42 Mpa and fulfills standard tensile strength commercial .

NOTATION

Surface area	A
Final weight	Wi
Initial weight	Wo

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REFERENCES

Arya Yudanto, Y. and Pudjihastuti, I. (2020) 'Characterization of Physical and Mechanical Properties of Biodegradable Foam From Maizena Flour and Paper Waste for Sustainable Packaging Material', *International Journal of Engineering Applied Sciences and Technology*, 5(8), pp. 1–8. doi: 10.33564/ijeast.2020.v05i08.001.

Choi, W. S. and Han, J. H. (2001) 'Physical and mechanical properties of pea-protein-based edible films', *Journal of Food Science*, 66(2), pp. 319–322. doi: 10.1111/j.1365-2621.2001.tb11339.x.

Kaisangsri, N., Kerdchoechuen, O. and Laohakunjit, N. (2012) 'Biodegradable foam tray from cassava starch blended with natural fiber and chitosan', *Industrial Crops and Products*, 37(1), pp. 542–546. doi: 10.1016/j.indcrop.2011.07.034.

Kumar, A. (2014) 'Pulp and paper-making potential of corn husk', *International Journal of AgriScience*, 4. (4), pp. 209–213.

Lee, R. S. *et al.* (2013) 'Influence of glycerol and water activity on the properties of compressed egg white-based bioplastics', *Journal of Food Engineering*, 118(1), pp. 132–140. doi: 10.1016/j.jfoodeng.2013.03.031.

Liu, Z. *et al.* (2019) 'Biodegradable and resilient poly (propylene carbonate)based foam from high pressure CO2 foaming', *Polymer Degradation and Stability*, 165, pp. 12–19. doi: 10.1016/j.polymdegradstab.2019.04.019.

Machado, C. M., Benelli, P. and Tessaro, I. C. (2020) 'Study of interactions between cassava starch and peanut skin on biodegradable foams', *International Journal of Biological Macromolecules*, 147, pp. 1343–1353. doi: 10.1016/j.ijbiomac.2019.10.098.

Mehraj, S. and Sistla, Y. S. (2022) 'Optimization of process conditions for the development of pectin and glycerol based edible films: Statistical design of experiments', *Electronic Journal of Biotechnology*, 55, pp. 27–39. doi: 10.1016/j.ejbt.2021.11.004.

Mustapha, S. N. H. and Wan, J. S. (2022) 'Effect of hybridization composition and glycerin content on novel corn starch/nata de coco plastic film: Thermal, mechanical, and degradation study', *Food Chemistry*, 373(PB), p. 131440. doi:

10.1016/j.foodchem.2021.131440.

Nansu, W. *et al.* (2021) 'Coconut residue fiber and modified coconut residue fiber on biodegradable composite foam properties', *Materials Today: Proceedings*, 47, pp. 3594–3599. doi: 10.1016/j.matpr.2021.03.623.

Sanhawong, W. *et al.* (2017) 'Effect of concentrated natural rubber latex on the properties and degradation behavior of cotton-fiber-reinforced cassava starch biofoam', *Industrial Crops and Products*, 108(July), pp. 756–766. doi: 10.1016/j.indcrop.2017.07.046.