



## Optimization of Temperature and Drying Time of Protein and Fat Levels of Black Soldier Fly (*Hermetia illucens*) Larvae

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**Abstract.** *Hermetia illucens* larvae have a high potential for treating waste as a feed ingredient rich in protein and fat. This research aims to determine the optimum temperature and drying time conditions to produce optimal yield, fat, and protein content. This research used the Response Surface Methodology (RSM) method with a Central Composite Design (CCD) design. This research uses two factors: a drying temperature of 60 - 800C and a drying time of 12 - 24 hours. The response variables measured were yield, fat content, and protein content. The research showed that a drying temperature of 720C for 12 hours provided an optimal solution for a yield of 26.23%, a crude fat content of 32.25%, and a crude protein content of 25.26%.

**Keywords:** Black Soldier Fly, Crude Fat Content, Crude Protein Content, Drying

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### INTRODUCTION

The need for feed in Indonesia every year continues to increase due to the growth of farmers and farmers' awareness of the use of concentrate feed, which is believed to guarantee product quality. One of the critical factors in the feed components is protein, fat, vitamins, and other nutrients. Protein for feed is generally obtained from blood meals, meat and bone meals, intestinal mucosal powder, fish meals, soybean meals, peanut meals, and cottonseed meals. The source of protein comes from waste, whose availability is often an obstacle. One source of protein that is now being developed is protein from *Black Soldier fly* (BSF) larvae.

BSF larvae have a reasonably high protein and fat content and a chewy texture, besides the ability to secrete natural enzymes. The protein content in larvae is around 42% (Faridah & Puguh, 2019). Fats and oils are used in poultry food formulations to improve food palatability and absorption of fat-soluble vitamins and to regulate the rate of digestive release in the gastrointestinal tract (Baião & Lara, 2005). Oil sources for feed are generally from plants. The addition of protein often requires two different components. BSF larvae are known as invertebrates that contain high amounts of protein and fat, so they are worthy of consideration as feed components.

BSF larvae (*Hermetia illusions* L) belong to the relatives of flies (family Diptera). The life cycle of BSF is divided into four phases: egg, larva, pupa, and adult. The content of BSF larvae can be used as an alternative to producing animal oil and has the potential to be a raw oil material (Jayanthi *et al.*, 2017) and a source of protein. The influence of time and high drying temperature will have an impact on the fat content in the material that is increasing, and the water content will decrease (Yuniarti, 2007).

Drying will facilitate the process of crushing materials, making it easier for the extraction process to produce crude fat content. Drying will also affect the value of protein levels produced from an animal product. According to Rosidin *et al.* (2012), the drying process will affect the fat and protein content value produced. According to Purnamasari *et al.* (2019), the drying process with too high a temperature in BSF larvae will cause changes in the value of *the primary nutrient*, namely protein, because it is denatured. One method of drying is to use an oven.

According to Irianto (1995), heating will form a shaft structure so that it will be related to protein bonds that form *aggregates*. This can facilitate the separation of liquids when pressing. High temperature and heating duration will result in a decrease in yield value. This is because the weight of water or water content in the material decreases due to heating (Erni *et al.*, 2018).

## **METHOD**

### **Tools and Materials**

The tools used in this study were members ovens, *goldfish*, and *Kendal*. The primary raw material in this study is *Black Soldier Fly Larvae*, *cultivated* at the Environmental Remediation Laboratory, Agricultural Engineering, Faculty of Agricultural Technology, Universitas Brawijaya. The solvents used in extraction are technical n-hexane and aquades.

### **Trial Plan**

This research uses the RSM method or *Response Surface Methodology* with a centralized composite point model with the help of *Design Expert software*. There are two test factors, the first being the drying temperature and the second being the length of drying time using the oven. The procedure for determining the experimental design in this study is as follows:

1. In this study, there were two factors consisting of drying temperature (X1) and drying time (X2). Each factor consists of three levels assigned code variables with -1, 0 and +1. For the lowest variable it is coded (-1), for the central variable it is coded (0) and for the highest variable it is coded (+1). The determination of levels at temperature and length of drying time is based on literature studies and preliminary research conducted. Where the

optimum temperature in *drying larvae* is 70°C for 18-24 hours which is used as the midpoint for determining the drying level (Purnamasari et al, 2019).

Factor I: Drying Temperature (A), there are three levels, namely:

$$X1 : (X1 = -1) = 60^{\circ}\text{C}$$

$$X1 : (X1 = 0) = 70^{\circ}\text{C}$$

$$X1 : (X1 = +1) = 80^{\circ}\text{C}$$

$$\text{Distance between factors} = 80 - 70 = 10^{\circ}\text{C}$$

Factor II: Length of Drying Time (B), there are three levels, namely:

$$X2 : (X2 = -1) = 12 \text{ Jam}$$

$$X2 : (X2 = 0) = 18 \text{ Jam}$$

$$X2 : (X2 = +1) = 24 \text{ jams}$$

$$\text{Inter-factor distance} = 24 - 18 = 6 \text{ Hours}$$

- Determination of factor levels in accordance with the center points of factors  $X1 = 0$  and  $X2 = 0$ . At the BSF larval drying temperature factor the relationship of variable  $X1$  with the original variable can be expressed in the equation as follows:

$$X1 = \frac{A-80}{10}; A = 10 X1 + 80 \dots (1)$$

In the factor of length of drying time the relationship of variable  $X2$  with the original variable can be expressed in the equation as follows:

$$X2 = \frac{A-18}{6}; B = 6 X2 + 18 \dots (2)$$

- Specifies the value of  $\alpha = 2^{k/4}$ . In the study used 2 factors, the value of  $k$  can be substituted as  $k = 2$ , so that  $\alpha = 2^{2/4} = 1.414$ . Then determine the appropriate factor level values, namely with values  $(-\alpha = -1.414)$  and  $(\alpha = 1.414)$  with the following calculation of variables  $X1$  and  $X2$ .

In equation (1) can be known:

- For  $X1 = -1.414$   
Thus,  $A = 10 (-1.414) + 70 = 55.8579^{\circ}\text{C}$
- For  $X1 = 1.414$   
Thus,  $A = 10 (1.414) + 70 = 84.1421^{\circ}\text{C}$

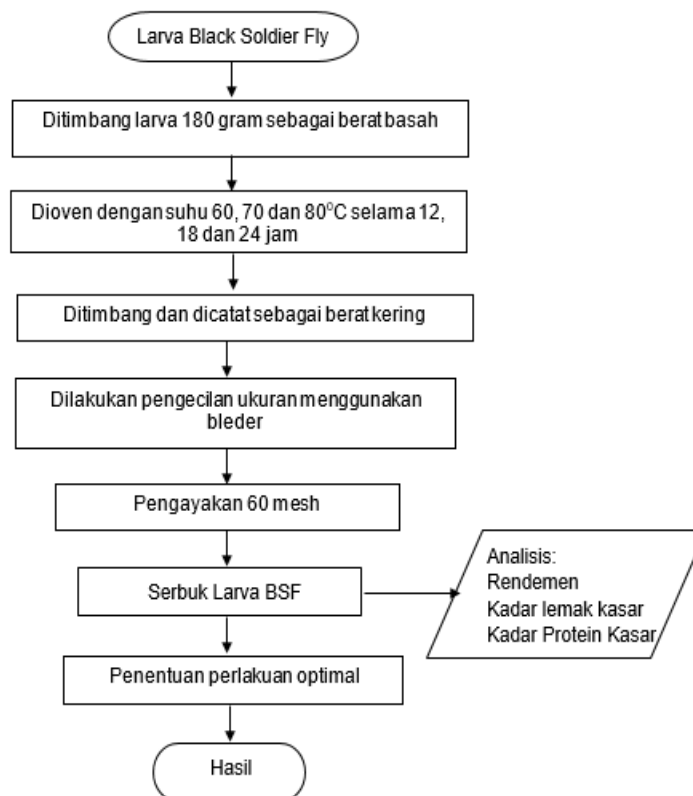
In equation (2) it can be known:

- For  $X2 = -1.414$   
Then,  $B = 6 (-1.414) + 18 = 9.51472 \text{ Hours}$
- For  $X2 = 1.414$   
Then,  $B = 6 (1.414) + 18 = 26.4853 \text{ Hours}$

**Table 1. Results of Experiment Design**

No	Factor		Factor			Response	
	X1	X2	Temperature (°C)	Time (Hour)	Rendeming (%)	Crude Fat Rate (%)	Crude Protein Content (%)
1.	-1	-1	60	12	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
2.	1	-1	80	12	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
3.	-1	1	60	24	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
4.	1	1	80	24	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
5.	-1,414	0	55,8	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
6.	1,414	0	84,1	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
7.	0	-1,414	70	9,5	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
8.	0	1,414	70	26,4	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
9.	0	0	70	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
10.	0	0	70	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
11.	0	0	70	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
12.	0	0	70	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>
13.	0	0	70	18	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>

**Stages of the drying process**



**Figure 1. Flow chart of Drying Process Stages**

### Yield Calculation

The yield is obtained by weighing the final weight resulting from the comparison process with the initial weight before undergoing the processing process.

$$\text{Rendemen} = (\text{SNI, 1988}). \frac{W_p}{W_a} \times 100\%$$

### Gross Fat Rate Calculation

Analysis of fat content is the separation of fat from the sample which is done by circulating fat solvents into the sample, so that in this case it will make other compounds insoluble in the solvent.

$$\text{Fat rate} = (\text{AOAC, 2005}). = \frac{D-C}{B-A} \times 100\%$$

### Calculation of crude protein levels

The setting of the content of coarse protein levels is carried out by the kjehdahl method. The rate of protein is determined based on the kjehdahl method as follows:

$$\text{Up to protein (\%)} = \frac{(D-C) \times n \text{ NaOH} \times 0,014 \times 6,25}{B-A} \times 100 \% (\text{AOAC, 2005}).$$

## DISCUSSION

### Respon Rendemen Larva *Black Soldier Fly* (BSF)

From the results of the analysis it is known that the yield value of BSF larvae ranges from 23-27% (Table 1).

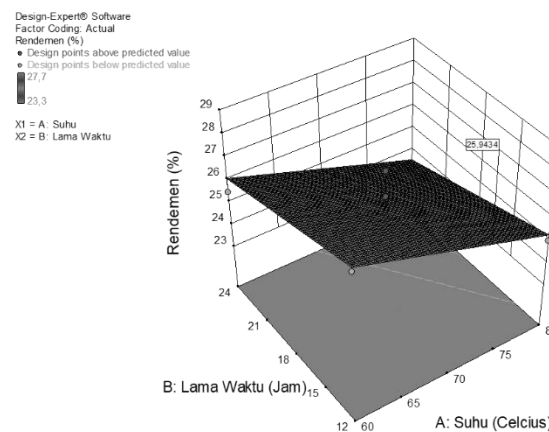
**Table 1 Yield of dried BSF larvae**

No	Factor X1	Factor X2	Temperature Factor (°C)	Time (Hour)	Response Rendemen (%)
1.	-1	-1	60	12	27,7
2.	1	-1	80	12	25
3.	-1	1	60	24	25,5
4.	1	1	80	24	23,3
5.	-1,414	0	55,8	18	27,2
6.	1.414	0	84,1	18	23,3
7.	0	-1,414	70	9,5	27,2
8.	0	1,414	70	26,4	25
9.	0	0	70	18	26,11
10.	0	0	70	18	27,2
11.	0	0	70	18	25,5
12.	0	0	70	18	25,5
13.	0	0	70	18	25,5

Based on Table 1, it is known that the highest yield is obtained at a temperature of 60<sup>0</sup>C and a 12-hour time of 27.7%. The lowest yield was obtained at 80 0C and 84.1 0C with a drying time of 24 hours and 18 hours of 23.3%.

$$\text{Polynomial equation } Y1 = 37.43 - 1.30 X1 - 0.146 X2; R2 = 0.8359$$

Based on the polynomial equation, it can be seen that temperature and drying time affect the yield response of BSF larvae linearly. This is because drying can change the texture of the material, such as the material wrinkling and the surface area of the skin shrinking (Rahmawati & Yudi, 2012). The results of ANOVA show that in the equation, it is known that the coefficient at the rigging temperature treatment (X1) has a more excellent value than the long drying time treatment (X2). From the Anova value, the R-squared value for the linear model obtained a value of 0.8359. This shows that the drying temperature influences the yield response of BSF larvae. The results are based on research conducted by Shadung et al. (2012), who found that a higher drying temperature will reduce yield. However, oven drying produces a higher material composition than *freeze drying*. This is in line with research conducted by Martunis (2012), with a yield response in potato starch with a temperature usage range of 40-600C obtained results that the use of 600C temperature results in a lower yield. This is because the use of higher temperatures causes more evaporated water content so that the yield produced decreases and vice versa.



**Figure 1. 3-dimensional plot contour yield response**

Figure 1. explains the influence of temperature factors and drying time on yield response. The graph shows that in the temperature range of 60-800C for BSF larval yield, the temperature rise significantly influences the yield decrease. Similar results were reported by Ikhsan et al. (2016) that drying in dumbo catfish at a temperature of 60 0C produces a higher water content compared to drying at 700C, where the higher the water content will be in harmony with the more significant the yield value. In the study of Cucikodana et al. (2012), drying above 600C in snakehead fish bones, the water content can decrease to 60-70%, resulting in a low yield value. In the drying process, there is heat transfer from air to the product under the influence of a temperature gradient, which causes water transfer through the evaporation process in the opposite direction due to the concentration of water in the air, resulting in a decrease in water content comparable to the yield (Bimbenet et al., 1971).

**Black Soldier Larvae Cheddar Fat Fly Up Response (BSF)**

The results of laboratory analysis showed that the value of crude fat content of BSF larvae ranged from 29-32% (Table 2).

**Table 2. Crude Fat Up Data Results**

No	Factor		Factor Temperature (°C)	Time (Hour)	Rate Response Crude Fat (%)
	X1	X2			
1.	-1	-1	60	12	30,16
2.	1	-1	80	12	31,07
3.	-1	1	60	24	30,75
4.	1	1	80	24	31,80
5.	-1,414	0	55,8	18	29,04
6.	1,414	0	84,1	18	31,37
7.	0	-1,414	70	9,5	31,90
8.	0	1,414	70	26,4	31,20
9.	0	0	70	18	33,03
10.	0	0	70	18	32,65
11.	0	0	70	18	32,70
12.	0	0	70	18	32,45
13.	0	0	70	18	32,95

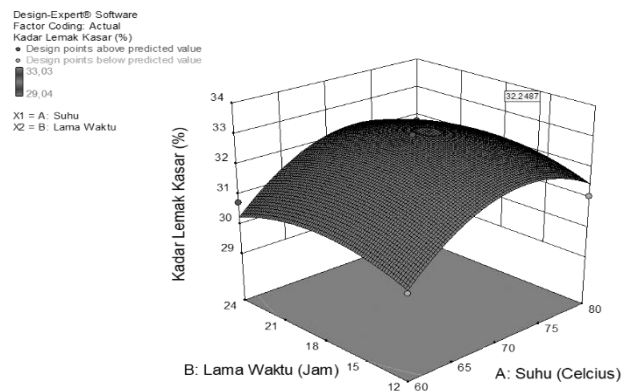
Based on Table 2. The highest fat content was obtained at a temperature of 700C with an 18-hour drying time of 33.03%. The lowest crude fat content was obtained from a temperature of 55.8°C with an 18-hour drying time of 29.04%.

Equation of regression of gross fat rate:

$$Y2 = -37,99 + 1,81 I1 + 0,55 I2 + 5,83 I1 I2 - 0,012 c12 - 0,016 c22$$

$$R2 = 0.9336$$

The ANOVA results show that the coefficient at the rigging temperature (X1) is greater than the drying time (X2). This shows that the response of BSF larvae to crude fat content is more influenced by drying temperature. This statement aligns with research conducted by Sipayung et al. (2015); the highest average fat content in crunch fish occurs at 80 0C temperature heating of 7.70%. This is also supported by the statement that states that the shrinkage of fat levels in fish is due to fluid loss in the cooking process (Dhanpal et al., 2012).



**Figure 2 3-dimensional plot contour response to crude fat content**

Figure 2 shows the highest crude fat content at 75 0C drying temperature and drying time for 12 hours with a predicted crude fat content of 32.24%. Drying in the temperature range of 60 – 700C continues to increase the value of crude fat content and the more extended drying. This statement aligns with research conducted by Riansyah et al. (2013) that shows that the crude fat content of Siamese seat fish continues to increase with the time used up to 24 hours, with a peak at a temperature of 700C of 2.19%. This is similar to research conducted by Purschke et al. (2018), which states that conventional drying in larvae is most significant using temperatures ranging from 60-80 0C.

**Response to Crude Protein Levels of Black Soldier Fly (BSF) Larvae**

The results of laboratory analysis showed that the value of crude protein content from BSF larvae ranged from 25-27% (Table 3).

**Table 3. Data Results for Crude Protein Levels**

No	Factor		Factor Temperature (°C)	Time (Hour)	Response Rate Raw protein (%)
	X1	X2			
1.	-1	-1	60	12	26,7
2.	1	-1	80	12	24,5
3.	-1	1	60	24	25,22
4.	1	1	80	24	22,5
5.	-1,414	0	55,8	18	27,3
6.	1,414	0	84,1	18	22,45
7.	0	-1,414	70	9,5	24,75
8.	0	1,414	70	26,4	23,8
9.	0	0	70	18	25,7
10.	0	0	70	18	25,9
11.	0	0	70	18	25,8
12.	0	0	70	18	25,8
13.	0	0	70	18	25,28

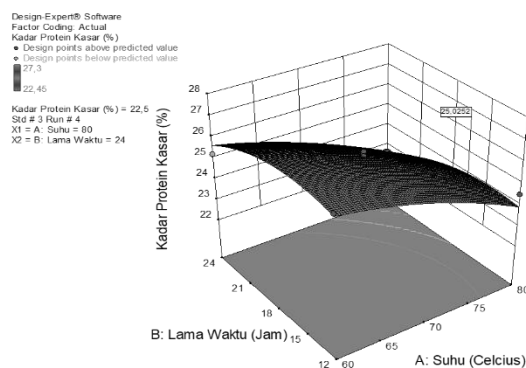
Based on Table 3. The highest crude protein content was obtained from a temperature of 55.80C with an 18-hour time of 27.30%. The lowest crude protein content was obtained at a temperature of 84.10C and an 18-hour time of 22.45%. Temperature factors and drying time affect the response of crude protein levels.

Protein bleaches as much as persamaan regress:

$$Y3 = 10,81 + 0,41 I1 + 0,72 I2 - 2,16 I2 - 3,71 c12 - 0,01 c22$$

$$R2 = 0.9484$$

The ANOVA results show that in the code equation, it is known that the coefficient in the drying temperature treatment (X1) has a more excellent value than the long drying time treatment (X2). This shows that the response of crude protein levels of BSF larvae is more influenced by drying temperature. Heating/drying done too long at too high a temperature will cause the protein to denature. Amino acids will be damaged in the heating process, where the resistance of the protein to heat is closely related to the amino acids that make up the protein. This decreases protein level readings as heating temperatures increase (Lisa et al., 2015). Proteins are easily affected by high temperatures, pH, and organic solvents (Meulisa et al., 2021). According to Hamzeh et al. (2019), drying carried out with different temperatures, namely 60, 70, and 800C, shows the results that with increasing temperature, protein content and water content in the product decreases.



**Table 5 Prediction of Optimum Solutions**

Parameter	Prediction Results
Drying Temperature	72 °C
Long Drying Time	12 jam
Rendeming	26,23 %
Crude fat content	32,25%
Crude Protein Content	25,26%
<i>Desirability</i>	0,641 %
Information	<i>Selected</i>

From Table 5. It was concluded that the optimal solution for drying was a temperature of 720C with a drying time of 12 hours. This factor will predict the yield value of BSF larvae by 26.23% with a prediction of crude fat content value of 32.25% and a prediction of crude protein content value of 25.26%. The acquisition of the desirability value to get the optimal value is 0.641%. The desirability value obtained in this study was 60%. The desirability value is low because the drying factor carried out does not get the desired response so that the desired program prediction has not been achieved.

**Table 6. Prediction of Lowest to Highest Solution Results**

Parameter	Predictions	<i>SE Pred</i>	Lowest Prediction	Ultimate Prediction	Actual Results	Difference	Validation
Rendeming (%)	26,23%	0,68	25,60	26,87	24,12 %	2,11	94,21%
Gross Fat Rate (%)	32,20 %	0,45	31,70	32,70	34,12 %	1,92	94,37%
Up to Protein Bleach (%)	25,26%	0,49	24,71	25,80	24,16 %	1.10	95,64%

From Table 6, several values are obtained: the prediction value, *SE-pred*, lowest prediction, and highest prediction of each response. Each value, namely for yield, has a prediction value of 25.23% and an *SE pred* value of 0.68%, with the lowest prediction of 25.60% and the highest prediction of 26.87%. Crude fat content has a prediction value of 32.20%, *SE pred* of 0.45%, with the lowest prediction value of 31.70% and the highest predicted value of 32.70%. For crude protein content, the value has a prediction value of 25.26% and an *SE pred* value of 0.49%, with the lowest prediction value of 24.71% and the highest prediction value of 25.80%. The test results again, with three iterations, obtained the actual result value. Tests are carried out with samples that are dried at the same temperature and length of time based on optimal results.

The temperature used is 720C, with a drying time of 12 hours. Table 6 provides validation results of each response with prediction values. For the yield, a validation value of 94.21% was obtained. Crude fat content obtained a validation value of 94.37%. Crude protein content obtained a validation value of 95.64%. Amran et al. (2014) stated that obtaining an accuracy value with results of more than 50% can be said that the model has the accuracy to predict optimal results.

## CONCLUSION

The results of research on optimizing the drying process for Black Soldier Fly larvae resulted in a combination of drying at a temperature of 720C for 12 hours, resulting in a predicted response for a yield of 26.23%, crude fat content of 32.25%, and crude protein content of 25.26%. The actual results obtained from each response were for a yield of 24.12%, crude fat content of 34.12%, and crude protein content of 24.16%.

## BIBLIOGRAPHY

- Association Of Official Analytical Chemist (AOAC). 2005. Peer Verified Method Program*
- Baiao N. C. and Lara L. J. C. 2005. Oil and Fat in Broiler Nutrition, *Brazilian Journal of Poultry Science*. 7(3): 129141.
- Bimbenet J, Loncin M, Brusset H. 1971. *Heat and mass transfer during air drying of solide. Thécandien. J. Chem. Engny.* 49: 860 - 865.
- Budiharjo A, Adi MPN, Lilik RK, Bayu SH. 2022. Aplikasi Teknologi Floating Catfish Pelet Sebagai Solusi Pemanfaatan Larva Black Soldier Fly di Mitra Usaha Mazgot Boyolali. 6(1): 14-22
- Cucikodana Y, Agus S, Budi P. 2012. Pengaruh Perbedaan Suhu Perebusan dan Konsentrasi NaOH Terhadap Kualitas Bubuk Tulang Ikan Gabus (*Chana striata*). *Fishteech*. 1(1): 91-101
- Dhanpal K, Reddy VS, Naik BB, Venkateswarlu G, Reddy AD, Basu S. 2012. *Effect of cooking on physical, biochemical, bacteriological characteristics and fatty acid profile of tilapia (Oreochromis mossambicus) fish steaks.* *Archives of Applied Science Research* 4(2): 1142-1149.
- Erni N, Kadirman, Ratnawaty F. 2018. Pengaruh Suhu dan Lama Waktu Pengeringan Terhadap Sifat Kimia Dan Organoleptik Tepung Umbi Talas (*Colocasia esculenta*). *Jurnal Pendidikan Teknologi Pertanian* 4(1): 95-105.
- Faridah F, Puguh C. 2019. Pelatihan Budidaya Maggot Sebagai Alternative Pakan Ternak di Desa Baturono Lamongan. *Jurnal Pengabdian Masyarakat* 2(1): 36-41
- Hamzeh S, Ali M, Sayed-Ahmad S, Mohammad A, Joe MR. 2019. *Effects of Drying Condition on Physico-chemical Properties of Foam-mat Dried Shrimp Powder.* *Journal Of Aquatic Food Product Technology*. 1-13.

- Ikhsan M, Muhsin, Patang 2016. Pengaruh Variasi Suhu Pengering Terhadap Mutu Dendeng Ikan Lele Dumbo (*Clarias gariepinus*). Jurnal Pendidikan Teknologi Pertanian 2(2): 114-122
- Irianto HE, Suryaningrum TD, Suparno, Muljanah. 1995. Penghambatan Pembusukan “Press Liquor” dan Pengolahan Tepung Ikan dengan Perlakuan Asam Formiat dan Pemanasan. Jurnal Penelitian Perikanan Indonesia. 1: 1-5
- Jayanthi S, Rita K, Herika, Muhammad A dan Rafiqah. 2017. Teknik Budidaya *Black Soldier Fly* (*Hermetica Illucens*). Jurnal Jeumpa 4(1):58-67.
- Lisa M, Musthofa LBS. 2015. Pengaruh Suhu dan Lama Pengeringan Terhadap Mutu Tepung Jamur Tiram Putih (*Plaerotus ostreatus*). Jurnal Keteknikan Pertanian Tropis dan Biosistem. 3(3): 270-279.
- Martunis 2012. Pengaruh Suhu dan Lama Waktu Pengeringan Terhadap Kuantitas dan Kualitas Pati Kentang Varietas Granola. Jurnal Teknologi dan Industri Pertanian Indonesia. 4(3): 26-30.
- Meulisa AI, Anhar R, Syarifah Z, Ikhsanul K. 2021. Kajian Mutu Kimiawi Tepung Tulang Ikan Tuna Sirip Kuning (*Thunus albacares*) dengan Suhu Pengeringan Yang Berbeda. Jurnal Perikanan Tropis 8(1): 35-43.
- Purnamasari L, Sucipto I, Muhlison W, Pratiwi N. 2019. Komposisi Nutrien Larva Black Soldier Fly (*Hermetia illucent*) Dengan Media Tumbuh, Suhu dan Waktu Pengeringan yang Berbeda. In Prosiding Seminar Nasional Teknologi Peternakan dan Veteriner. Bogor, 13 Januari
- Purschke B, Henrik B, Rafaela S, Henry J. 2018. *Efect Of Pre-Treatment And Drying Method On Physico-Chemical Properties And Dry Fractionation Behaviour Of Mealworm Larvae (Tenebrio Molitor L.)*. Eur Food Res Technol. 244: 269-280
- Rahmawati H dan Yudi P. 2012. Rendemen dan Komposisi Proksimat Gelatin Kulit Ikan Belut Dan Lele Pada Keadaan Segar Dan Kering . Fish Science. 2(4): 111-123.
- Riansyah A, Agus S, Rodiana N. 2013. Pengaruh Perbedaan Suhu dan waktu Pengeringan Terhadap Karakteristik Ikan Asin Sepat siam (*Trichogaster pectoralis*) Dengan Menggunakan Oven. Fish Tech 2(3): 53-68.
- Rosidin, Kiki Y, Siti HRJ. 2012. Pengaruh Suhu dan Lama Pengeringan Terhadap Mutu Sitase Limbah Pengolahan Kodok Beku (*Rana sp.*) Yang Dikeringkan Dengan Penambahan Dedak Padi. Jurnal Unsri Fishtech 1(01): 79-91.
- Shadung KG, Mphosi MS, Mashela PW. 2012. *Influence of drying method and location on proximate chemical composition of African metallic wood boring beetle, Sternocera orissa (Coleoptera: Buprestidae) in Republic of South Africa*. African Journal of Food Science 6: 155-158.
- Sipayung MY, Suparmi, Dahlia. 2015. Pengaruh Suhu Pengukusan Terhadap Sifat Fisika Kimia Tepung Ikan Rucah. Jurnal Online Mahasiswa Fakultas Perikanan dan Ilmu Kelautan Universitas Riau. 2(1): 1-13.
- SNI. 1988 . Standar Nasional Indonesia 06-3735-1998 Standar Mutu Minyak Atsiri. Badan Standarisasi Nasional. Jakarta

Yuniarti, ND, Syamssuwida dan A. Aminah. 2007. Pengaruh penurunan kadar air terhadap perubahan fisiologi dan kandungan biokimia benih eboni (*Diospyros celebica* *Bahk.*). Jurnal Penelitian Hutan Tanaman. Teknologi Pembenihan Bogor 5(3): 191-198