PAPER • OPEN ACCESS

Shelf-life Prediction of Gluten-Free Dry Noodles Made from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) Using Accelerated Shelf-life Testing (ASLT) Method with Arrhenius Equation Approach

To cite this article: F Violalita *et al* 2021 *IOP Conf. Ser.: Earth Environ. Sci.* **757** 012057

Shelf-life Prediction of Gluten-Free Dry Noodles Made from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) Using Accelerated Shelf-life Testing (ASLT) Method with Arrhenius Equation Approach

F Violalita[1], H F Yanti[1], R Novita[1], Evawati[1], S Syahrul[1], K Fahmy[2]

[1] Department of Food Technology, Agricultural Polytechnic State of Payakumbuh, Jalan Raya Negara Tanjung Pati Km 7 – 26271, Indonesia

[2] Department of Agricultural and Biosystem Engineering, Faculty of Agricultural Technology, Andalas University, Kampus Limau Manis, Padang-25163, Indonesia

Corresponding author's email address: fidelaviolalita@gmail.com

Abstract. Research on gluten-free noodles made from composite flour (modified cassava flour (mocaf), tapioca, cornstarch, and soybeans) has been carried out in previous studies. However, research on the shelf life of these noodles has not been carried out. Information on shelf life is intended to ensure product quality is in good condition when consumed and does not endanger consumers' health. This research aims to determine the shelf life of gluten-free dry noodles made from composite flour (mocaf, tapioca, cornstarch, and soybeans). Determination of gluten-free dry noodles' shelf life using Accelerated Shelf Life Testing (ASLT) with the Arrhenius approach based on the pattern of changes in water content. Gluten-free dry noodles are packed using polypropylene plastic with a thickness of 0.09 mm. The packaged noodles were then stored at different temperatures, 25°C, 35°C, and 45°C. The parameter observed was moisture content on days 0, 14, 28, 35, and 42 days. The result showed that water content tends to increase during storage of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans). Gluten-free dry noodles from the composite flour (mocaf, tapioca, cornstarch, and soybeans) stored at 25°C had the most suitable shelf life, around 161 days.

Keywords: gluten-free, dry noodles, shelf life, ASLT

1. Introduction

The community is increasingly developing gluten-free foods. This shows that people are increasingly concerned about the effect of gluten on health, especially in people with Celiac Disease or people with autism. In previous research, gluten-free noodles were made from modified cassava flour (mocaf flour), tapioca flour, cornstarch, and soybeans flour. Based on this research, it is known that the best gluten-free noodles are produced from noodles made from mocaf flour, tapioca flour, and cornstarch with the addition of 15% soy flour. Gluten-free wet noodles with substitution of 15% soybeans flour are the best treatment that produces noodles with a characteristic water content of 61.18%, the ash content of 0.56%, protein content of 6.96%, fat content of 4.68%, carbohydrates 23.30%, crude fiber content of 3.33%, 27.50% elasticity, 102.29% water absorption, 69.18% swelling index, and 11.39% cooking loss. The organoleptic analysis result showed that panelists favored gluten-free noodles in terms of texture and appearance. In terms of The panelist's color, aroma, and taste provide a neutral assessment [1].

The analysis results show that gluten-free noodles made from mocaf, tapioca, and cornstarch substituted with soybeans flour have enormous potential to be developed in the community. However, it is unknown how long the shelf life of dry gluten-free noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans). The shelf life of gluten-free dry noodles made of composite flour (mocaf, tapioca, cornstarch, and soybeans) needs to be known so that consumers know how long these noodles can be stored and consumed.

A food product shelf life is the time interval between production and consumption. The product is in a satisfactory condition based on the characteristics of appearance, taste, aroma, texture, and nutritional value. During the storage and distribution process, the product will experience a decrease in quality both in sensory and nutrition [2]. Information on shelf life is intended to ensure product quality is in good condition when consumed and does not endanger consumers' health. The accelerated shelf-life test (ASLT) method is a method that can be used to determine the shelf life of a food product.

The approach to determining the shelf life of food products with the ASLT method is carried out by storing the product in the environment, accelerating the decline in product quality [3]. Estimating shelf life using the ASLT method is carried out with the Arrhenius approach, which accelerates the occurrence of product quality degradation reactions at extreme storage temperature conditions, which are then carried out mathematical calculations. Based on this background, an estimation of the shelf life of gluten-free noodles made from composite flour will be carried out.

The purpose of this study was to determine the shelf life of gluten-free noodles made of composite (mocaf, tapioca, cornstarch, and soybeans). Shelf-life testing will describe how long the product can last at the same quality during the storage process.

2. Materials and Methods

2.1 Materials and Tools

The ingredients used in the manufacture of gluten-free noodles were mocaf, tapioca, cornstarch, soybeans flour, eggs, CMC, salt, and coconut oil. The tools used to make gluten-free noodles are a pot, stove, spoon, sieve, scale, tray, noodle maker, mixer. The tools used to analyze gluten-free noodles were aluminum plates, desiccator, oven, analytical scale, and sealer.

2.2 Research Implementation

2.2.1 Making Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) (Violalita et al. 2020 modified [1])

The noodles were made by mixing the ingredients of mocaf, tapioca flour, cornstarch flour and soybeans, CMC, salt, beaten egg, and coconut oil for 15 minutes using a mixer. After the dough is finished, the dough is formed into sheets and then molded to become noodles. Noodles that have been formed are then steamed for 15 minutes and then dried in a drying oven at 60°C for 20 hours. Gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) will be obtained from the drying result. The dry noodles are then packed using Polypropylene plastic with a thickness of 0.09 mm.

2.2.2 Storage of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans)

Noodles that have been packed with polypropylene plastic are then stored in an incubator at various temperatures. The storage temperature for the noodles is conditioned at 25°C, 35°C, and 45°C. The observations made were water content analysis using the thermogravimetric method [4] and free fatty acid levels using the acid number titration method [4] on days 0, 14, 28, 35, and 42.

IOP Conf. Series: Earth and Environmental Science 757 (2021) 012057 doi:10.1088/1755-1315/757/1/012057

2.2.3 Estimated Shelf Life of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybean Flour) using the Accelerated Shelf-life Testing (ASLT) Method with the Arrhenius Equation Approach.

Estimation of shelf life begins with a graph of the relationship between storage time (days) on the x-axis and the average loss of quality/day on the y-axis. The plot of values is carried out in the orders 0 and 1. After that, perform linear regression with the x-axis representing 1 / T and the y-axis representing ln Ea / R, where T is the storage temperature used. Data from the analysis of each parameter is plotted against time (days). The linear regression equation is obtained so that four equations are obtained for the four conditions of product storage temperature y = a + bx. Where y = product characteristic value, x = storage time (days), b = characteristic change rate, a = initial quality characteristic value. The slope or bx will be the same as Ea / RT, and the intercept or a will be the same as ln ko.

Arrhenius equation:

$$k = k_0 . e^{-\left(\frac{E_a}{RT}\right)} \tag{1}$$

with k is constant of temperature drop, k0 is Constant independent of temperature, Ea is activation energy (cal / mol), R is gas constant (1.986 (cal / mol °K), and T is absolute temperature (°K).

The equation in logarithmic form:

$$\ln k = \ln k_0 - \left(\frac{E_a}{R}\right)\frac{1}{T} \tag{2}$$

with k is constant deterioration, k0 is constant independent of temperature, Ea is Activation energy (cal / mol), R is gas constant (1.986 (cal / mol °K), and T is absolute temperature (°K).

The equation for estimating shelf life:

$$t \text{ order } 0 = \frac{Ao - A}{k} \tag{3}$$

$$t \text{ order } 1 = \frac{\ln Ao - \ln A}{k} \tag{4}$$

with t is Predicted shelf life (days), A0 is initial quality value, A is The value of product quality remaining after time t, and k is constant deterioration at normal temperature.

3. Results and Discussion

3.1 Quality Observation During Storage

3.1.1 Water Content

Dry noodles have a low moisture content, so that they can be stored relatively long at room temperature. Gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) had a water content at the beginning of storage of 4.53%. The noodles obtained are following the established standards. According to SNI 01-2774-1992, the moisture content requirement for quality I dry noodles is a maximum of 8%, while for quality II a maximum of 10% [5]. In the research of making dry noodles made from cassava flour and mocaf, the moisture content of dry noodles ranged from 8-10% [6].

The water content of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) tended to increase at storage temperature 25°C, 35°C, and 45°C. The water content value of the noodles at 25°C ranged from 4.53% - 5.98%. At 35°C storage, the water content of noodles ranged from 4.53% - 5.51%. At a storage temperature of 45°C, the water content of noodles ranged from 4.53% - 5.34%. The change in water content of gluten-free noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) during storage can be seen in Figure 1.

The change in water content was caused by differences in environmental humidity with the gluten-free dry noodle samples. When the partial pressure of ambient water vapor is greater than the vapor pressure in the package, water vapor from the environment will move into the sample. This is in accordance with Elisabeth and Simbolon's research, which states that if the environment relative humidity is high enough, the material will absorb some water from the environment to adjust the environment's relative humidity. This resulted in increased water content [7,8]. Factors that can cause an increase in the water content of food during storage include the permeability of packaging materials to moisture, hygroscopic properties of packaged food items, and environmental humidity levels for food products [7].

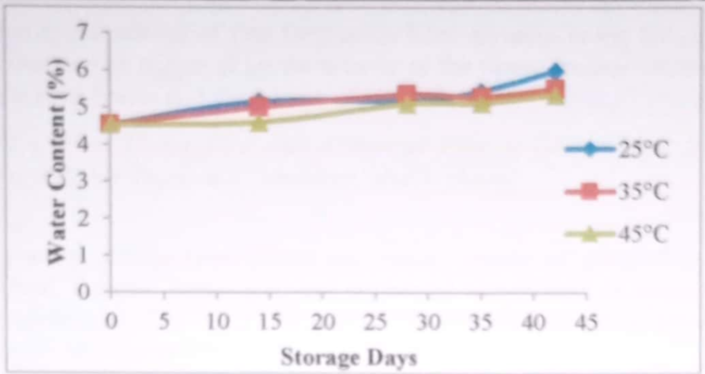

Figure 1. Changes in Water Content of Gluten-Free Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) during Storage

3.1.2 *Free Fatty Acid (FFA)*

Increased levels of free fatty acids can be used as an indication of rancidity in a food product. High free fatty acid (FFA) levels reflect low product quality. The primary damage to fat is the appearance of a rancid odor and taste. This is because fat is easy to absorb odors. Rancidity can be caused by hydrolysis or oxidation reactions [9].

Gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) had 0.17% free fatty acid content at the beginning of storage (on day 0). The free fatty acid content of gluten-free dry noodles tended to increase both at 25°C, 35°C, and 45°C. Changes in free fatty acid levels of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) during storage can be seen in Figure 2. The value of free fatty acid levels of noodles at a storage temperature of 25°C ranges from 0.17% - 0.24%. At 35°C storage, the free fatty acid content of noodles ranged from 0.17% - 0.23%. At a storage temperature of 45°C, the free fatty acid content of noodles ranged from 0.17% - 0.31%.

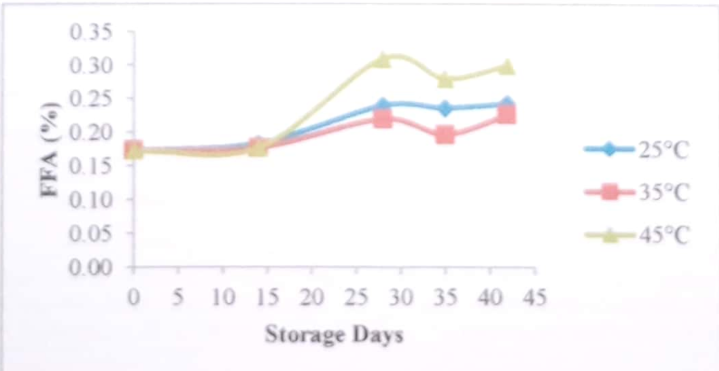

Figure 2. Changes in the free fatty acid content of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) during storage

This study's result was also consistent with the study of changes in the free fatty acid content of dry noodles from maize and cassava composite flour. The free fatty acid levels during storage also tend to increase. This increase in FFA occurs at every storage temperature, but at extreme temperatures, these changes occur faster than if stored at low temperature and room temperature [10].

In the hydrolysis reaction of oils and fats, it is converted into free fatty acids and glycerol, which can cause damage to oils and fats. This occurs due to the presence of a certain amount of water in the oil and fat, resulting in the fat being hydrolyzed. This occurs due to the presence of a certain amount of water in the oil and fat. This can result in the taste and odor of rancid fat. Fat hydrolysis reaction or lipolysis is a reaction to the release of free fatty acids from glycerin in the fat's molecular structure. The hydrolysis reaction can be triggered by the activity of the lipase enzyme or heating, which causes the termination of the ester bonds and the release of free fatty acids [11]

3.2 Zero Order Plot, First Order Plot and Arrhenius Plot of Gluten-Free Dried Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybean)

3.2.1 Water Content

The relationship between storage time (days) and water content of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) was plotted in zero order and first order based on storage temperatures of 25 °C, 35 °C, and 45 °C. Zero-order reaction plots and the first-order reaction plots are shown in Figures 3 to 8.

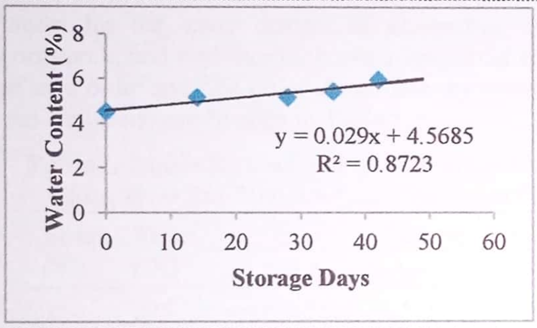

Figure 3. Zero Order Plot of Water Content of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 25 °C Storage.

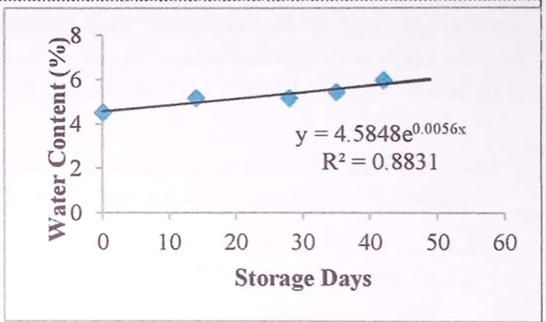

Figure 4. First Order Plot of Water Content of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 25 °C Storage.

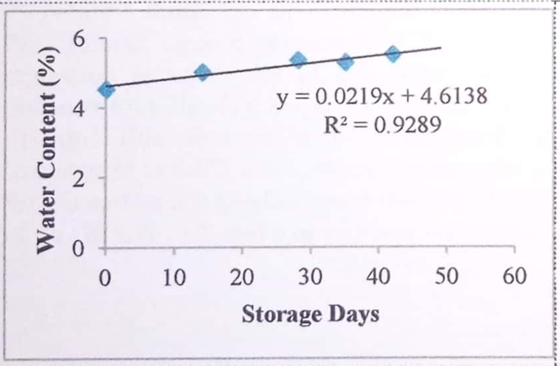

Figure 5. Zero Order Plot of Water Content of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 35 °C Storage.

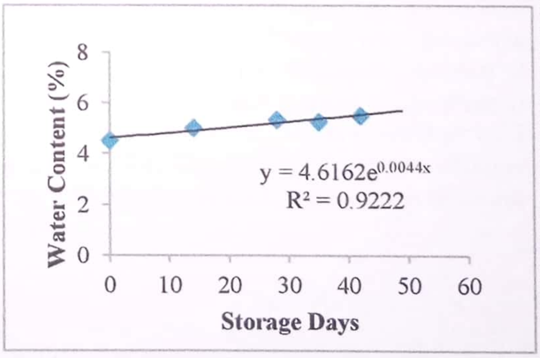

Figure 6. First Order Plot of Water Content of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 35 °C Storage.

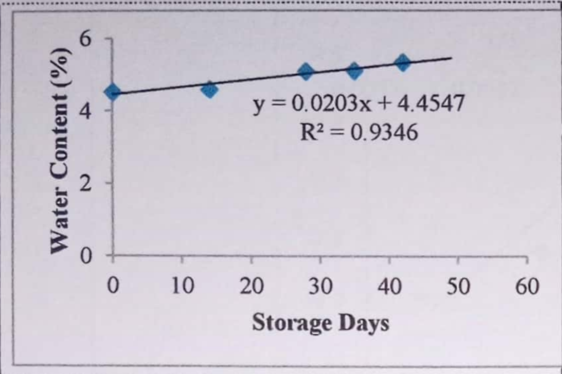

Figure 7. Zero Order Plot of Water Content of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 45 °C Storage.

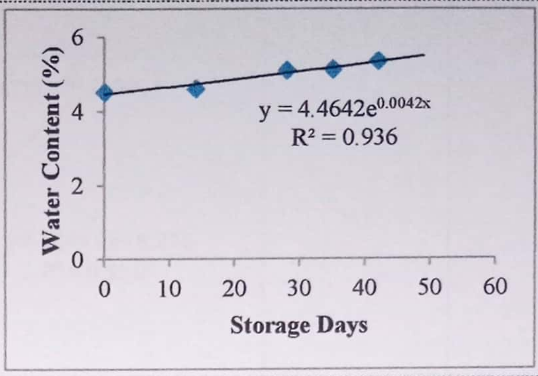

Figure 8. First Order Plot of Water Content of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 45 °C Storage.

Based on the Figure above, it is obtained a linear regression equation of each storage temperature in zero order and first order; from the linear line equation, the slope, intercept, and correlation values are obtained. Based on the linear regression equation for each storage temperature in zero order and first order, the coefficient of determination (R^2) of zero-order is higher than first order. The prediction model for the water content of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) follows a zero-order reaction rate. Linear regression equation water content of zero order and first order gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) can be seen in Table 1.

Table 1. Linear Regression Equation Water Content of Zero Order Water Content and First Order Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans)

Temp (°C)	Temp (°K)	Reaction Equation		R^2	
		Zero Order	First Order	Zero Order	First Order
25	298	y = 0,0290x + 4,5685	$y = 4,5848^{e0,0056x}$	0,8723	0,8831
35	308	y = 0,0219x + 4,6138	$y = 4,6162^{e0,0044x}$	0,9289	0,9222
45	318	y = 0,0203x + 4,4547	$y = 4,4642^{e0,0042x}$	0,9346	0,9360

Figure 8 shows that the Arrhenius model of water content parameters for gluten-free dry noodles flour (mocaf, tapioca, cornstarch, and soybeans). This Arrhenius model is obtained from the linear regression equation plot of zero-order for each storage temperature. The Arrhenius equation is obtained from the first slope (k) value in Ln so that the Ln k value of each storage temperature is obtained. This value will be plotted against the storage temperature, which is first converted to 1 / T sequentially to fulfill the Arrhenius equation Ln k = Ln ko - Ea / RT. The Arrhenius equation obtained for gluten-free dry noodles is y = 1699.9x - 9,276 (y = ax + b) where y is Ln k, a or slope is the value of Ea / R, x is 1 / T, and b or intercept is the value of Ln ko.

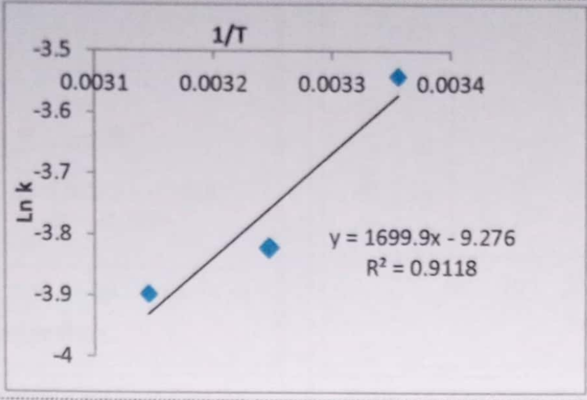

Figure 9. The plot of Arrhenius from water content parameters of Gluten-Free Dried Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans)

3.2.2 Free Fatty Acid (FFA)

The relationship between storage time (days) and free fatty acid of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) was plotted in zero order and first order based on storage temperatures of 25 °C, 35 °C, and 45 °C. Zero-order reaction plots and the first-order reaction plots are shown in Figures 9 to 14.

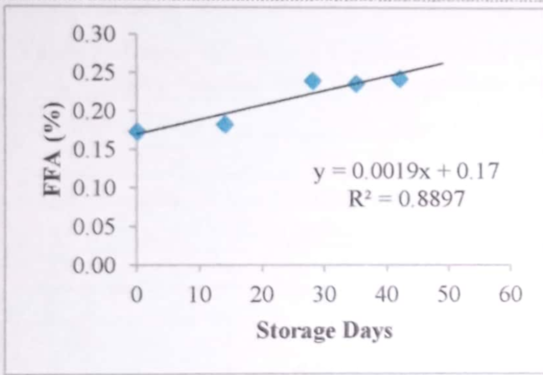

Figure 10. Zero Order Plot of FFA of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 25 °C Storage.

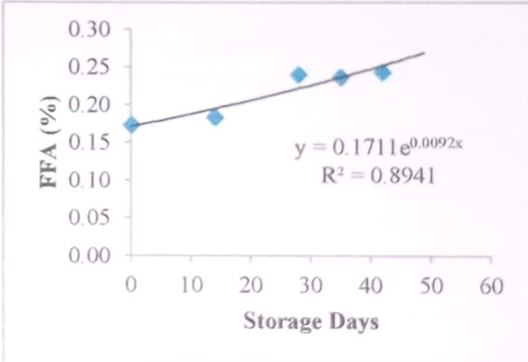

Figure 11. First Order Plot of FFA of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 25 °C Storage.

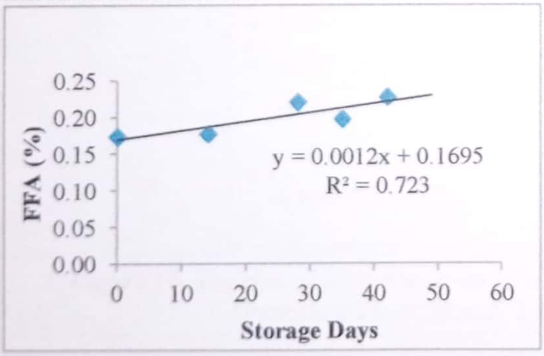

Figure 12. Zero Order Plot of FFA of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 35 °C Storage.

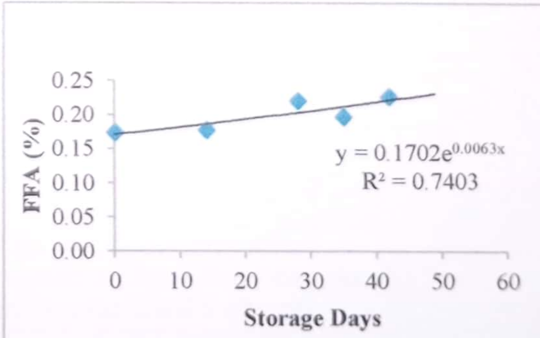

Figure 13. First Order Plot of FFA of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 35 °C Storage.

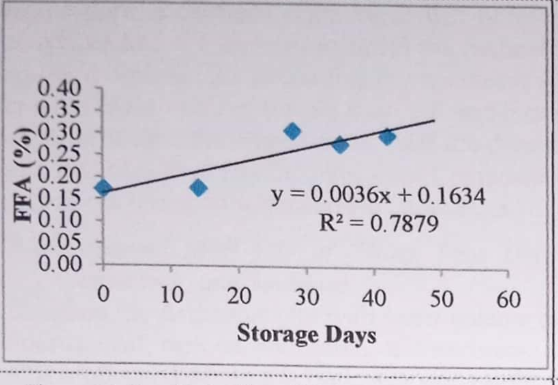

Figure 14. Zero Order Plot of FFA of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 45 °C Storage.

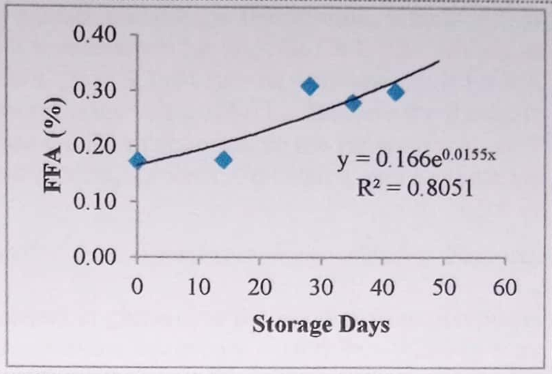

Figure 15. First Order Plot of FFA of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans) at 45 °C Storage.

Based on the Figure above, it is obtained a linear regression equation of each storage temperature in zero order and first order; from the linear line equation, the slope, intercept, and correlation values are obtained. Based on the linear regression equation for each storage temperature in zero order and first order, the coefficient of determination (R^2) of zero-order is lower than first-order. Linear regression equation FFA of zero order and first order gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) can be seen in Table 2.

Table 2. Linear Regression Equation FFA of Zero Order Water Content and First Order Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybeans)

Temp (°C)	Temp (°K)	Reaction Equation		R^2	
		Zero Order	First Order	Zero Order	First Order
25	298	y = 0,0019x + 0,1700	$y = 0{,}1711^{e0{,}0092x}$	0,8897	0,8941
35	308	y = 0,0012x + 0,1695	$y = 0{,}1702^{e0{,}0063x}$	0,7230	0,7403
45	318	y = 0,0036x + 0,1634	$y = 0{,}1660^{e0{,}0155x}$	0,7879	0,8051

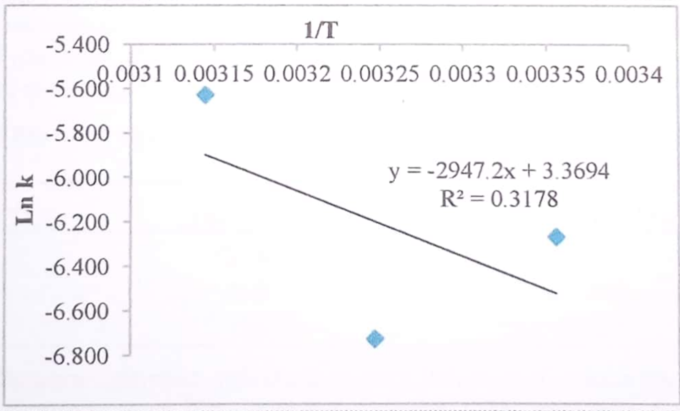

Figure 16. The plot of Arrhenius from FFA parameters of Gluten-Free Dried Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch and Soybeans)

In Figure 16, the Arrhenius model of water content parameters for gluten-free dry noodles flour (mocaf, tapioca, cornstarch, and soybeans) is shown. This Arrhenius model is obtained from the linear regression equation plot of zero-order for each storage temperature. The Arrhenius equation is obtained from the slope (k) value, which is first in Ln so that the Ln k value of each storage temperature is obtained. This value will be plotted against the storage temperature, which is first converted to 1 / T in order to fulfill the Arrhenius Ln k equation = Ln ko - Ea / RT. The Arrhenius equation obtained for gluten-free dry noodles is y = -2947,2x + 3,3694 (y = ax + b) where y is Ln k, a or slope is the value of Ea / R, x is 1 / T, and b or intercept is the value of Ln ko. Because the R2 value obtained is low, the estimation of shelf life does not use the FFA parameter, so the estimation of shelf life of Gluten-Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybean) is carried out based on water content parameters.

3.3 Estimated Shelf Life of Gluten Free Dry Noodles from Composite Flour (Mocaf, Tapioca, Cornstarch, and Soybean)

Based on the Arrhenius plot with water content parameters in gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans). A straight-line equation y = 1699.9x - 9,276 (y = ax + b) is obtained where y is Ln k, a or slope is the value of Ea / R, x is 1 / T, and b or intercept is the Ln ko value. Based on the straight-line equation obtained y = - 9,276 + 1699,9x then:
Ea / R = 1699.9
Ln ko = - 9,276

Based on the above values, the equation for estimating the gluten-free dry noodles' shelf life from composite flour (mocaf, tapioca, cornstarch, and soybeans) $k = 0.00094e^{1699.9\,(1/T)}$ is obtained, so that the k value of each storage temperature is obtained. The k value of each storage temperature can be seen in Table 3.

Table 3. K values of each Gluten Free Dry Noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) Storage Temperature

Temp (°C)	1/T	Ln k	k
25	0,0034	-3,5405	0,3042
35	0,0032	-3,8213	0,2165
45	0,0031	-3,8971	0,1827

After the k value (quality deterioration constant) at each storage temperature is obtained, then the estimation of the age of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) can be done in equation 3. Based on the Arrhenius model calculation, the determinant of shelf-life gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) is based on water content parameters, namely at 25oC for 161 days, 35°C for 194 days, and 45°C for 231 days. The shelf life of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) can be seen in Table 4.

Table 4. The shelf life of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans)

Temp (°C)	Temp (°K)	Shelf Life (Days)
25	298	161
35	308	194
45	318	231

This study's results were consistent with research from Palupi *et al.*, where the shelf life of dry corn noodles at a storage temperature of 28°C reaches 4,6 months (138 days) [12]. According to Elizabeth and Setijorini, the shelf life of dry noodles made from composite flour, taro, and sweet potato at 30°C is 46 weeks (324 days) [7]. According to Haryadi's research, sago starch noodles' shelf-life with a water content of 11% is 6-12 months [13].

4. Conclusions

From the research conducted, it can be concluded the water content and free fatty acid content of gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybeans) tend to rise during storage. To predict shelf life based on content parameters because the coefficient of determination (R^2) is higher (0.9118) than the FFA value, meaning that the storage temperature influences the value of water content. Gluten-free dry noodles from composite flour (mocaf, tapioca, cornstarch, and soybean flour) at a storage temperature of 25°C have a shelf life of 161 days, at a storage temperature of 35°C have shelf life 194 days and at a storage temperature of 45°C have a shelf life 231 days.

References

[1] Violalita, F., Evawati., Syahrul, S., Yanti, H.F., Fahmy, K. 2020. Characteristics of Gluten-Free Wet Noodles Substituted with Soy Flour. IOP Conference Series: Earth and Environmental Science 515 (2020) 012047.
[2] Herawati, H. 2008. Penentuan Umur Simpan pada Produk Pangan. Jurnal Litbang Pertanian, 27(4), 2008: 124-130.
[3] Asiah, N., Cempaka, L., David, W., 2018. Panduan Praktis Pendugaan Umur Simpan Produk Pangan. Penerbitan Universitas Bakrie. Jakarta.
[4] AOAC. 1995. Official Method Of Analysis of Association Of Official Of Analytical Chemistry, and Analytical Aspect. AOAC: Washington
[5] [BSN] Badan Standarisasi Nasional. 1992. SNI 01-2974-1992. Mi Kering. Badan Standarisasi Nasional: Jakarta.
[6] Mariyani, N. 2011. Studi Pembuatan Mie Kering Berbahan Baku Tepung Singkong dan Mocaf (Modified Cassava Flour). Jurnal Sains Terapan, Vol. 1 (1):9-11.
[7] Elisabeth, D. A. A., Setijorini, L. E. 2016. Pendugaan Umur Simpan Mi Kering dari Tepung Komposit Terigu, Keladi, dan Ubi Jalar. Jurnal Matematika, Sains dan Teknologi, Vol. 17 No.1, Maret 2016:20-28.
[8] Simbolon, N. P, E., Legowo, A. M., Setiani, B. E. 2019. Estimation of Shelf Life Pasta Spice for Dekke Mas Na Niura with the Accelerated Shelf Life Test (ASLT) Method Arrhenius Equation. Journal of Applied Food Technology 6(2): 22–27.
[9] Kusnandar, F. 2010. Kimia Pangan Komponen Makro. PT. Dian Rakyat. Jakarta.
[10] Kumalasari, R., Desnilawati, D., Wadhesnoeriba, S.P. 2018. Evaluasi Mutu Kimia dan Organoleptik Mi Kering Bebas Gluten dari Tepung Komposit Jagung-Singkong selama Penyimpanan. Jurnal Ilmu Pertanian Indonesia (JIPI), Desember 2018 Vol. 23 (3):173-182.
[11] Mamuaja, C. F. 2017. Lipida. Unsrat Press. Manado.
[12] Palupi, N. S., Kusnandar, F., Adawiyah, D. R., Syah, D. 2010. Penentuan Umur Simpan dan Pengembangan Model Diseminasi dalam Rangka Percepatan Adopsi Teknologi Mi Jagung bagi UKM. Manajemen IKM, Februari 2010, Vol. 5 No. 1:42-52.
[13] Haryadi, 2002. The current status and future prospects of sago palms in Java. In: Kainuma, K., Okazaki, M., Toyoda, Y. and Cecil, J. E., (eds.) 2002. New frontiers in sago palm studies.Proceedings of the International Symposium on Sago (Sago 2001), Oktober 15-17, Tsukuba. Universal Academy Press, Inc., Tokyo.