

Shelf life estimation of hanjeli flakes with eel flour using accelerated shelf life testing (ASLT) method and Arrhenius model

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Abstract. Hanjeli flakes with eel flour are flat-shaped biscuit cereals made from hanjeli flour and eel flour. Shelf life information about the product is needed to ensure that the product is still suitable for consumption. This research aims to estimate the shelf life of hanjeli flakes with eel flour based on variations in packaging at different temperatures and times using the Accelerated Shelf Life Testing method Arrhenius model. This method was carried out at three storage temperatures, 15, 30, and 45°C, for 35 days and observed every seven days with water content, hardness, fracturability (crispness), and total mold. Based on the results of the research shelf life estimation of hanjeli flakes with eel flour, the best type of packaging is aluminum foil packaging because it can further extend the shelf life of the product compared to polypropylene packaging. These findings indicate that aluminum foil packaging can effectively extend the shelf life and maintain the quality of hanjeli flakes enriched with eel flour, which were 88.72 days (based on the water content parameter), 189.50 days based on the hardness parameter, 119.60 days based on fracturability (crispness), and 177.18 days based on total mold parameter.

1 Introduction

Recent developments have seen changes in people's lifestyles and consumption, requiring practical and nutritious products, such as breakfast cereals. Health-conscious consumers are looking for gluten-free and nutrient-rich breakfast products [1]. Most cereal flakes products in Indonesia made from wheat flour, and to obtain wheat, Indonesia still carries out import activities from other countries. In response to this, there are many cultivation products substitutes for wheat in Indonesia, one of which is the hanjeli plant which can be optimized and processed into flour. Hanjeli flour contains high levels of vegetable protein [2].

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Job's tears (*Coix lacryma-jobi* L.) is a cereal from the Gramineae (Poaceae) family that serves as both food and feed [3]. Its grains can be eaten as staples, for example as porridge or rice-like kernels [4]. Nutritionally, hanjeli provides about 67–76% carbohydrates, 14–20% protein, and various micronutrients. Per 100 g of dehulled seed, it contains 10.1–15.0 g water, 58.3–77.2 g carbohydrates, 9.1–23.0 g protein, 0.3–8.4 g fiber, 0.5–6.1 g fat, 0.7–2.6 g ash, and roughly 1500 kJ of energy [4]. Compared with other cereals—including sorghum, rice, and corn—hanjeli tends to be higher in protein, fat, vitamin B1, and calcium.

Flake cereals that have been circulating in the market mainly only serve ready-to-eat products without paying attention to the nutritional balance in the product [5]. Hanjeli as the main ingredient of cereal flakes is rarely used. Nowadays, consumer demand for breakfast is shifting to a functional, fast food and nutritious breakfast product. For development of hanjeli flour flakes products to achieve a nutritional balance, several types of fish are added, one is eel fish because eel fish is rich in nutrients such as protein, omega-3, calcium, minerals, phosphorus, and so forth. The eel fish is a valuable commodity favored across East and Southeast Asia for its superior flavor, and it is now commercially farmed using floating cage systems [6]. The addition of eel fish in the development of flake products can support the habit of the Indonesian people to consume fish. The creation of a cereal product based on hanjeli and eel fish can be an alternative food rich in energy, protein, and other nutrients.

Flakes hanjeli eel flour is a cereal like flat-shaped biscuit made from hanjeli flour and eel flour. One of the quality criteria that needs to be present in food products is shelf life. The problem that occurs a lot in instant products is that they quickly absorb water from the air (hygroscopic) and cause a decrease in quality which affects the shelf life [1]. Applying packaging technology can maintain the durability of flakes products. Packaging aims to allow packaged products to be accommodated and protected. Packaging is one of the efforts to extend the shelf life of food products [7]–[10]. The accelerated shelf-life testing (ASLT) method is widely utilized to enhance the efficiency of determining a product's storage stability and lifespan. Among the variables applied to accelerate degradation, temperature serves as the most prevalent factor. The resulting kinetic data are often interpreted through the Arrhenius equation, which provides a mathematical framework for forecasting product durability and acts as a predictive model for shelf-life estimation [11]. In evaluating food stability, the accelerated storage approach applies concepts from chemical reaction kinetics to measure how environmental conditions like heat and moisture contribute to degradation processes. This procedure exposes products to higher-than-normal levels of one or more external variables, thereby speeding up the breakdown reactions and effectively shortening the time required to observe quality loss [12].

Research on the formulation and development of the manufacture flakes hanjeli eel flour products has been carried out by [13], related to the development of eel flour hanjeli flakes products have not been carried out studies that examine the estimation of shelf life, so research was carried out on estimating the shelf life of flakes hanjeli eel flour based on packaging variations using the Accelerated Shelf Life Testing (ASLT) method of the Arrhenius model.

2 Materials and Methods

2.1 Materials and equipment

The ingredients used for hanjeli flakes with eel flour are hanjeli flour, eel flour, rice flour, eggs, sugar, milk powder, condensed milk, baking powder, 14x22 cm aluminum foil standing pouch packaging with a thickness of 120 microns, and polypropylene (PP) standing pouch of 14x22 cm with a thickness of 80 microns.

The ingredients used for analysis are sterile water, Potato Dextrose Agar (PDA), and Buffered Peptone Water (BPW). The tools used in making cereal flakes are a pressure steamer, cabinet dryer, oven, dough sheeter, digital balance sheeter, chopper, mixer, and plastic spatula. The tools used in the analysis process are steam cups, ovens, excavators, spatulas, digital balance sheets, incubators, petri dishes, micron pipettes, blue tips, erlenmeyer, test tubes, and Texture Analyzer.

2.2 Shelf life estimation

Hanjeli flakes with eel flour are packaged in a standing pouch aluminum foil size 14x22 cm with a thickness of 120 microns and a standing pouch polypropylene (PP) size of 14x22 cm with a thickness of 80 microns. Then storage at temperatures of 15°C, 30°C, and 45°C was tested for water content analysis, mold count analysis, and texture analysis (hardness and crispness). The research is conducted at intervals once every seven days until the 35th day and the water content and mold count were tested. Texture hardness and crispness tests were measured using the TA-XT2 texture analyzer (Stable Microsystems), with a three-point bend rig (Biscuit Bending) type probe.

Estimation of shelf life is carried out based on with several stages [14], namely first, the results of the analysis data that have been obtained in the plot into the form of a curve so that a linear regression will be obtained $y = a + bx$, where the value of b obtained as k from the linear regression equation, then if these values of k are applied in the formula Arrhenius $\ln k = \ln k_0 - E_a / RT$, where $\ln k_0$ is a constant, E_a is the activation energy, and R is the gas constant which is 1.986 cal/mol K).

Since $\ln k_0$ and $-E/R$ are constant numbers, the equation can be written as follows: $\ln k = A + B (1/T)$ So that if every value of k and $1/T$ is plotted in a graphs. After that, each value of k and $1/T$ is planned in a graph, thus the importance of E can be obtained as follows:

$$-E/R = B \quad (1)$$

Slope value B is generated from the linear regression equation between $\ln k$ and $1/T$, and the value of k_0 is obtained as follows:

$$\ln k_0 = A \quad (2)$$

The model or equation for the rate of deterioration is as follows:

$$k = k_0 \cdot e^{-E_a/RT} \quad (3)$$

If it has been known the value of k (the magnitude of the decrease in quality), then calculated shelf life (ts) is used the following equation:

Kinetic equations for the order zero ($n=0$):

$$ts = (A_s - A_o)/k \quad (4)$$

Kinetic equations for order one ($n=1$):

$$ts = [\ln (A_s/A_o)]/k \quad (5)$$

Information:

A_o = initial quality

A_s = final quality (quality of products that are not suitable for consumption)*

ts = expiration time

*value obtained from SNI value 01-2973-1992 as well as related preliminary research [15] (Water Content 5%, Hardness 936 gF, Crispness 29,551 mmF, mold count 100 cfu/g)

3 Results and Discussion

3.1 Water content

Water content is the percentage of the water content of a material expressed based on wet weight (wet basis) or based on dry weight (dry base) [16]. Water content is an essential parameter in determining the shelf life of a product because it affects physicochemical properties, chemical changes, and microbiological damage to foodstuffs. The results of the water content of eel flour flakes hanjeli on packaging stored at different temperatures and times can be seen in Table 1.

Table 1. Water Content (%) Hanjeli Flakes

Day	Water Content (%)					
	Aluminium Foil			Polypropylene		
	15°C	30°C	45°C	15°C	30°C	45°C
0	3.17	3.17	3.17	3.17	3.17	3.17
7	3.25	3.38	3.41	3.33	3.48	3.65
14	3.49	3.67	3.76	3.59	3.72	4.08
21	3.53	3.78	3.80	3.80	3.82	4.31
28	3.80	3.84	3.93	3.89	4.04	4.65
35	3.89	3.92	4.22	4.29	4.56	4.73

In table 1, the water content of the eel flour hanjeli flakes stored in the package and different temperatures for 35 days increased. The highest water content is at 45°C. An increase in water content value indicates a decrease in product quality.

The higher the storage temperature, the higher the increase in water content. This is influenced because the dried food product has hygroscopic properties compared to the original product. After all, the product that undergoes the drying process (dry product) has many pores so, it quickly absorbs water. In addition, because the water content in the product is low and the surrounding RH is high, there will be the absorption of water vapor so that the water content becomes higher [17].

3.2 Texture

The quality of dry products or cereals, such as flakes, will decrease as the product ages. During the product storage process, it will experience several changes caused by interactions with various factors, including extrinsic and intrinsic factors. Extrinsic factors of the environment include air, oxygen, water vapor, light, and temperature, while intrinsic factors include the product's composition. Dry food products, including flake damage, are more often associated with damage to texture [18].

The hardness and crispness of a product is an essential physical character to analyze because it is directly related to the sensory acceptance of food products. Table 2 shows that over 35 days, the storage of flakes at each temperature and different packaging values of hardness tends to increase. The value of violence is inversely proportional to the value of

crispness, where the lower the hardness, the better the crispness. The increase in hardness is due to an increase in the amount of water that fills the pores of the food air.

Crispness is an important quality criterion of various cereal products or dry products. The crispness of low-water food products is affected by water content and will be lost due to the plasticization of physical structures by temperature or water [19].

Because the values of crispness and hardness are inversely proportional, based research estimating the shelf life of flakes hanjeli eel flour states that the value of hardness up to day 35 is more significant. The value of crispness is higher, which indicates the force needed to break the product is more effective because the hardness value is higher than during storage flakes lose crispness. The results of the analysis of crispness can be seen in table 3.

The hardness and crispness of flakes are also affected by the water content. The increase in water content in the eel flour hanjeli flakes up to day 35 causes the product to become mushy and tough (loss of fragility). Flakes have a crispy texture and break easily due to friction or pressure caused by their thin texture. Flake damage can be caused by a decrease in the degree of crispness. The reduction in the crispness of the flakes occurs because the flakes absorb water. The chemical composition of the product, especially the water content determines the crispness properties. The lower of water content of a product, the crisper the product will be. Storage of the product for 35 days causes the product to absorb water and lose crispness.

Table 2. Hardness Value (gF) Hanjeli Flakes

Day	Hardness (gF)					
	Aluminium Foil			Polypropylene		
	15°C	30°C	45°C	15°C	30°C	45°C
0	301.209	301.209	301.209	301.209	301.209	301.209
7	321.517	318.136	371.520	322.104	437.845	496.190
14	338.467	457.683	499.108	491.255	513.323	513.441
21	373.424	483.860	500.546	496.889	533.744	557.812
28	377.744	506.515	549.947	442.697	543.620	567.790
35	409.320	520.601	587.276	482.686	570.959	623.313

Table 3. Crispness Value (mmF) Hanjeli Flakes

Day	Crispness (mmF)					
	Aluminium Foil			Polypropylene		
	15°C	30°C	45°C	15°C	30°C	45°C
0	1.295	1.295	1.295	1.295	1.295	1.295
7	1.178	2.514	2.858	1.330	2.902	3.210
14	1.412	2.960	3.048	1.374	3.490	3.536
21	1.314	3.096	3.118	1.619	3.422	3.722
28	1.802	3.042	3.160	2.164	3.262	3.862
35	2.730	3.223	3.325	3.335	3.539	3.941

3.3 Total mold

The role of microbiological aspects in assessing the quality of food products is essential because some types of food products quickly experience a decline in quality. Nutrients and the content of food products can be a growth medium for microorganisms.

One of the safety parameters of a product is the mold number. The purpose of conducting a mold count test is to ensure that a product is safe for consumption. Mold growth on the product can reduce food quality because mold produces harmful toxins. The value of the amount of mold on the flakes hanjeli of eel flour can be seen in table 4.

The increase in the value of the number of molds can be caused by the use of aluminum foil and polypropylene packaging, so this is in line with the results of the study where the amount of mold in aluminum foil packaging is lower than the amount of mold in polypropylene packaging which is caused because aluminum foil packaging has a lower permeability than polypropylene so that it is not quickly passed by water vapor.

Thick and tightly enclosed packaging can limit the increasing moisture content of the product, which plays an important role in the process of microbial proliferation (proliferation) in the product during storage.

Table 4. Total Mold (cfu/g) Hanjeli Flakes

Day	Mold (cfu/g)					
	Aluminium Foil			Polypropylene		
	15°C	30°C	45°C	15°C	30°C	45°C
0	16	16	16	16	16	16
7	23	27	30	25	28	29
14	27	30	34	28	33	38
21	30	33	35	30	37	40
28	34	34	38	35	38	45
35	33	35	41	38	43	47

3.4 Estimation of shelf life

After the data were obtained, a graph of order 0 and a graph of order one were made to determine the exact order for estimating product's shelf life. A mapping of the water content parameter against the time for the zero reaction order was carried out, and mapping the yield parameter in water content for the reaction order one. The reaction order with the highest coefficient of determination (R^2) value is the most suitable or selected reaction order in determining the estimation shelf life of flakes, The value of R^2 and the selected order of each parameter can be seen in table 5.

Table 5. Determination of the Selected Order of Hanjeli Flakes with Eel Flour

Parameters	Packaging	T (°C)	R2 Order 0	R2 Order 1	The Largest R2	Selected Order
Water Content	Aluminium Foil	15	0.9711	0.9721	Order 1	Order 0
		30	0.9201	0.9077	Order 0	
		45	0.9569	0.9490	Order 0	
	Polypropylene	15	0.9758	0.9819	Order 1	Order 1
		30	0.9540	0.9650	Order 1	

Parameters	Packaging	T (°C)	R2 Order 0	R2 Order 1	The Largest R2	Selected Order
		45	0.9595	0.9379	Order 0	
Hardness	Aluminium Foil	15	0.9787	0.9795	Order 1	Order 0
		30	0.8697	0.8453	Order 0	
		45	0.9198	0.8839	Order 0	
	Polypropylene	15	0.5940	0.6192	Order 1	Order 0
		30	0.8128	0.7550	Order 0	
		45	0.8021	0.7269	Order 0	
Crispness (Fracturability)	Aluminium	15	0.6718	0.7141	Order 1	Order 0
		30	0.7029	0.6331	Order 0	
		45	0.6235	0.5613	Order 0	
	Foil	15	0.7573	0.8345	Order 1	Order 0
		30	0.5788	0.5382	Order 0	
		45	0.6779	0.5918	Order 0	
Total Mold	Polypropylene	15	0.9061	0.8558	Order 0	Order 0
		30	0.8065	0.7286	Order 0	
		45	0.8256	0.7280	Order 0	
	Aluminium	15	0.9496	0.8072	Order 0	Order 0
		30	0.8997	0.7999	Order 0	
		45	0.8949	0.8558	Order 0	

After the selected reaction order is obtained, the value of $k=b$ in the regression equation of each parameter is presented in Table 6. Then the value of k is plotted into a graph with $1/T$ as the x-axis and $\ln k$ as the y-axis. From the relation curve, $\ln k$ to $1/T$ obtained the linear regression equation of each parameter. The curve of the relationship of $\ln k$ with $1/T$ can show that the smaller the value of $\ln K$, the greater the value of $1/T$, while if the value of b (regression coefficient) is negative, it indicates that there is a decrease in $\ln K$ of each parameter by a temperature increase of $1/T$. Both equations can be obtained from the value of the activation energy (E_a) and the constant value of the deterioration (k) at a temperature of 15°C , 30°C , and 45°C , presented in Table 7.

Table 6. Linear Regression Equation of Storage Time (Day) Relationship Curve with Hanjeli Flakes Parameter

Parameters	Packaging	T (K)	Regression Equation	b=k	ln k	1/T
Water Content	Aluminium Foil	288	$y = 0.0216x + 3.1438$	0.0216	-3.8350	0.00347
		303	$y = 0.0214x + 3.2524$	0.0214	-3.8444	0.00330
		318	$y = 0.028x + 3.2257$	0.0280	-3.5756	0.00314
	Polypropylene	288	$y = 0.0083x + 1.1520$	0.0083	-4.7915	0.00347
		303	$y = 0.0094x + 1.1643$	0.0094	-4.6671	0.00330
		318	$y = 0.0114x + 1.2023$	0.0114	-4.4741	0.00314
Hardness	Aluminium	288	$y = 3.0375x + 300.46$	3.0375	1.11103	0.00347
		303	$y = 6.8909x + 310.74$	6.8909	1.93020	0.00330

Parameters	Packaging	T (K)	Regression Equation	b=k	ln k	1/T
	Foil	318	$y = 8.0288x + 327.76$	8.0288	2.08304	0.00314
	Polypropylene	288	$y = 5.2033x + 331.75$	5.2033	1.64929	0.00347
		303	$y = 6.8837x + 362.99$	6.8837	1.92916	0.00330
		318	$y = 7.6314x + 376.41$	7.6314	2.03227	0.00314
Crispness (Fracturability)	Aluminium	288	$y = 0.0365x + 0.9826$	0.0365	-3.31044	0.00347
		303	$y = 0.0464x + 1.8769$	0.0464	-3.07046	0.00330
		318	$y = 0.0454x + 2.006$	0.0454	-3.09224	0.00314
	Foil	288	$y = 0.0528x + 0.9280$	0.0528	-2.94124	0.00347
		303	$y = 0.0499x + 2.1113$	0.0499	-2.99773	0.00330
		318	$y = 0.0627x + 2.1630$	0.0627	-2.76939	0.00314
Total Mold	Polypropylene	288	$y = 0.4939x + 18.524$	0.4939	-0.70542	0.00347
		303	$y = 0.4857x + 20.667$	0.4857	-0.72216	0.00330
		318	$y = 0.6122x + 21.619$	0.6122	-0.49076	0.00314
	Aluminium	288	$y = 0.5796x + 18.524$	0.5796	-0.54542	0.00347
		303	$y = 0.6898x + 20.429$	0.6898	-0.37135	0.00330
		318	$y = 0.8367x + 21.190$	0.8367	-0.17829	0.00314

Activation energy is the energy required to activate a damage reaction that can be calculated using the Arrhenius equation. The greater the activation energy, the slower the reaction to damage because the minimum energy for the response to occur is more significant. The relationship between activation energy and damage reaction is inversely proportional [20].

The activation energy value obtained is the energy needed to increase the moisture content, hardness, crispness, and amount of mold on the flakes. The value of E is obtained from the formula $-E/R = B$, or the value of $-E/R$ is the value of b (regression coefficient) of the graph of the relationship of $1/T$ with $\ln k$. Value R is the constant gas value, which is 1.986 cal/mol. The greater the value of the activation energy, the slower the reaction rate. The determination of the value of k_0 is obtained from the formula $\ln k_0 = A$, or the value of k_0 is the value of a (regression constant). The value of k (deterioration constant) on each package and storage temperature can be known using the formula $k = k_0 \cdot e^{-E_a/RT}$. The value of k indicates that the magnitude of the value of k on the eel flour hanjeli flakes during storage is determined by the temperature and type of packaging used. The higher the temperature, the higher the value of k in the product, and the higher the value of k, the faster the rate of decline in product quality. The value of the activation energy (E_a) and the constant value of deterioration (k) at temperatures of 15°C, 30°C, and 45°C are presented in Table 7. The magnitude of the value k in eel flour hanjeli flakes during storage is determined by the temperature and type of packaging with different permeability. The higher the storage temperature, the greater the value of k.

Table 7. Constant Deterioration of Eel Flour Hanjeli Flakes

Parameters	Packaging	T (°C)	E_a (cal/mol)	k_0	Quality Loss Constant (k)
Water Content	Aluminium Foil	15	1544.29	0.3069	0.02063
		30			0.02358

Parameters	Packaging	T (°C)	Ea (cal/mol)	ko	Quality Loss Constant (k)
	Polypropylene	45	1915.68	0.2333	0.02661
		15			0.00819
		30			0.00967
		45			0.01123
Hardness	Aluminium Foil	15	5954.82	111301.721	3.34976
		30			5.60854
		45			8.94477
	Polypropylene	15	2337.72	317.793	5.33478
		30			6.53114
		45			7.84462
Crispness (Fracturability)	Aluminium	15	1348	2.494	0.23625
		30			0.26548
		45			0.29507
	Foil	15	1012.58	3.378	0.57519
		30			0.62788
		45			0.67975
Total Mold	Polypropylene	15	1275.99	4.413	0.474085
		30			0.529443
		45			0.585137
	Aluminium	15	2222.14	28.045	0.57622
		30			0.69842
		45			0.83131

From the calculation results in Table 7, it can be calculated that the shelf life of eel flour hanjeli flakes with a consumption limit value or critical value according to SNI 01-2973-1992, states the moisture content in cereal products or dry products such as flakes is a maximum of 5%. Calculations are made based on the selected order.

On aluminum foil packaging, the moisture content parameter of the selected order 0, and the Polypropylene packaging of the order chosen, namely order 1. Based on the calculation results, the shelf life of hanjeli flakes presented in Table 8 is obtained.

Table 8. Shelf Life of Hanjeli Flakes Eel Flour Water Content Parameters

Packaging	T (°C)	Shelf Life
Aluminium Foil	15	88.72 Days
	30	77.62 Days
	45	68.77 Days
Polypropylene	15	56.96 Days
	30	45.57 Days
	45	41.43 Days

Based on the results of research estimating the shelf life of eel flour flakes with moisture content parameters, the best product storage, namely by storing flakes in aluminum foil packaging at a temperature of 15°C, has a shelf life of 88.72 days or two months 28 days. From the calculation results in Table 7, it can be calculated the shelf life of eel flour hanjeli flakes based on the selected order, where the packaging of Aluminum foil and Polypropylene (PP), parameters of the crispness of the selected order is order 0, then the shelf life presented in Table 9 is obtained.

Table 9. Shelf Life of Hanjeli Flakes Eel Flour Hardness

Packaging	T (°C)	Shelf Life
Aluminium Foil	15	189.50 Days
	30	113.18 Days
	45	70.97 Days
Polypropylene	15	118.99 Days
	30	97.20 Days
	45	80.92 Days

Based on the results of research estimating the shelf life of eel flour flakes with hardness parameters, the best product storage, namely by storing flakes in aluminum foil packaging at a temperature of 15°C, has a shelf life of 189.50 days or six months 9 days.

From the calculation results in Table 7, the shelf life of eel flour hanjeli flakes can be calculated based on the selected order, where the packaging of Aluminum foil and Polypropylene (PP), the crispness parameter of the selected order is order 0, then the shelf life presented in Table 10 is obtained.

Table 10. Shelf Life of Hanjeli Flakes Eel Flour Crispness (Fracturability)

Packaging	T (°C)	Shelf Life
Aluminium Foil	15	119.60 Days
	30	106.43 Days
	45	95.76 Days
Polypropylene	15	49.12 Days
	30	45 Days
	45	41.57 Days

Based on the results of research estimating the shelf life of eel flour flakes with crispness (fracturability) parameters, the best product storage, namely by storing flakes in aluminum foil packaging at a temperature of 15°C, has a shelf life of 119.60 Days or 3 months 29 Days.

From the calculation results in Table 7, it can be calculated the shelf life of eel flour hanjeli flakes with a consumption limit value or a critical value on dry products such as flakes similar to biscuits according to, SNI 01-2973-1992 states the amount of mold in cereal products or dry products such as flakes which is a maximum of 100 CFU/g then calculated based on the selected order, where the packaging of Aluminum foil and Polypropylene (PP) the crispness parameter of the selected order is order 0. The shelf life presented in Table 11 is obtained.

Table 11. Shelf Life of Hanjeli Flakes Eel Flour Total Mold

Packaging	T (°C)	Shelf Life
Aluminium Foil	15	177.18 Days
	30	158.66 Days
	45	143.56 Days
Polypropylene	15	145.78 Days
	30	120.27 Days
	45	101.05 Days

Based on the results of research estimating the shelf life of eel flour hanjeli flakes based on total mold parameters, the best product storage, namely by storing flakes in aluminum foil packaging at a temperature of 15°C has a shelf life of 177.18 Days or 5 months 27 Days.

Packaging plays an essential role in determining the shelf life of products. The most important properties of the packer include gas and moisture permeability as well as the surface area of the packaging. Packaging with good gas inhibition and a smaller surface area leads to the longer shelf life of the product.

Aluminum foil packaging with a thickness of 120 microns already has a function as good packaging for dry packaging products such as flakes because it has a water vapor transmission rate (WVTR) of 0.0768 g/cm²/24 hours and an oxygen transmission rate (O₂TR) of 0.3199 cc/m²/24 hours, while for Polypropylene packaging with a thickness of 80 microns has a water vapor transmission rate (WVTR) of 41.320 g/cm²/24 hours and an oxygen transmission rate (O₂TR) of 678.188 cc/m²/24 hours. It can be concluded that aluminum foil packaging can extend the shelf life and maintain product quality based on the low value of steam transmission rate (WVTR) and oxygen transmission rate value (O₂TR) compared to polypropylene packaging [21].

4 Conclusion

Based on research on estimating the shelf life of eel flour hanjeli flakes at different temperatures and packaging, it can be concluded that the higher temperature and storage time on the parameters of moisture content, hardness, crispness, and amount of mold, the product decreases in quality. This type of aluminum foil packaging produces a longer shelf life than Polypropylene (PP) packaging because aluminum foil packaging has translucent properties, is resistant to tears, and has better thickness and permeability than Polypropylene (PP). These findings support the use of aluminum foil packaging for commercial production of fortified flakes with extended marketability.

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