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Estimation of Shelf Life of Rinuak Fish Nugget (Psilopsis, SP) With the addition of Sago Flour And Pumpkin Using The Arrhenius Method

Lili Marlina [1], Novelina [2], Anwar Kasim [2]

[1]Student of Postgraduate Program Of Agricultural Industrial Technology, Andalas University, Padang, West Sumatera, Indonesia

[2]Faculty of Agriculture Technology, Andalas University, Padang, West Sumatera, Indonesia

Abstract--This study aims to obtain the formula for making rinuak nuggets that are most preferred by the panelists. The formula was prepared by varying the rinuak fish, sago flour and pumpkin. The most preferred formula by the panelists was then tested for shelf life using the Arrhenius method . The results showed that the formula nugget most preferred is the treatment of C (rinuak fish : flour Sago: pumpkin = 70%: 15%: 15%). The results of further research until the 30th day of storage at a temperature of -15°C still have good quality , in This is assessed from the number of microbes and the percentage of water content that is still in accordance with the established standards.

Keywords--Rinuak Fish, Nugget , Sago Flour, Pumpkin, Shelf Life, Arrhenius

I. Introduction

Indonesia is a maritime country that has wide waters that are rich in marine life, there are several regions that are the largest fish producers in Indonesia so that many types of fish are exported abroad. However, there are several types of fish that are not yet known by the public, one of which is a small size fish, namely rinuak fish. Rinuak fish is an endemic fish that only exists in Lake Maninjau.

Rinuak fish is a freshwater fish measuring 18 mm which can only be found in Lake Maninjau, this type of fish is often found around Lake Maninjau and usually people around the lake use this fish as palai, bakwan, and other traditional foods [1].

Rinuak fish is one of the sources of income for the people around Lake Maninjau area. Rinuak fish are not only sold raw but also processed into various forms of food that greatly support the economy of the surrounding community. So that the processed rinuak is known by people outside Maninjau with various better developments.

The rinuak fish had disappeared from Lake Maninjau due to the contamination of the lake due to the large number of wild cages that damaged water quality so that many marine animals died suddenly. After the actions of the government and the local community, the Maninjau lake has recovered. So that the production of rinuak fish is abundant again and the development of products made from rinuak fish can be done.

Nugget is one of the development of nutritious and durable food products. The use of this rinuak fish in making *nuggets is* expected to increase the economy of the Maninjau community towards rinuak fish and can meet the needs of animal protein for its consumers, especially rinuak fish has a distinctive and savory taste.

Nugget is a type of food made from ground beef or minced meat that is seasoned, and shaped into a certain mold, then steamed, cut into pieces according to size, baked, frozen, and before consuming it is fried [2]

Making *nuggets* requires a binder to produce a good quality product. In general, the binder that is often used is various types of flour containing carbohydrates such as wheat flour, glutinous rice flour, cornstarch and others. However, there is another type of flour that has the potential and has high carbohydrates that can be used as an ingredient for making *nuggets,* namely sago flour.

Sago is a potential crop in Indonesia. However, its utilization has not been maximized and needs to be improved in modifying processed food products using sago. Sago flour is a source of carbohydrates that are quite easy to obtain for the community. In addition to being high in carbohydrates, sago also has high starch and has a distinctive taste. Sago flour can be used as a binder in the manufacture of *nuggets,* it is shown that its properties can bind water in the dough. Usually in the manufacture of *nuggets* using a binder in the form of wheat flour, while the price of wheat flour is relatively more expensive than sago flour.

Pumpkin(*Cucurbita moschata* Duschenes) is one of the local food ingredients that has good nutritional value for the human body. Pumpkin plants can grow in the lowlands and highlands so that they are also suitable for growing in West Sumatra, especially the districts of Solok, Agam and Tanah Datar which have quite large pumpkin potential. Solok Regency according to West Sumatra data in 2011 figures, the planted area reaches 45 hectares with a total production of 1,025 tons [3]

One of the uses of pumpkin is used as a raw material for making fish *nuggets* . The use of pumpkin flesh in the manufacture of fish *nuggets* is more profitable than the use of pumpkin flour. Besides being easier than flour processing and the time used is also shorter, the use of pumpkin meat also reduces the loss of nutrients in the processing. In addition, the use of pumpkin flesh also plays a role in improving the texture and color of the *nuggets* themselves.

Judging from the processing process by steaming and freezing, fish *nuggets* are classified as foods that are easily damaged, especially if stored at room temperature, but will be different if storage is carried out at freezing temperatures.

Nugget susceptible to microbial growth - pathogenic microbes such as *Staphylococcus aureus* and *Salmonella.* Storage of *nuggets* is one of the factors so that the quality of nuggets is maintained. In the storage process, errors that may be made are temperature and storage time so that it will affect the quality of the nuggets.

Packaging also plays an important role in protecting food from environmental influences such as light, heat, oxygen, humidity, microorganisms, such as insects, dust, gas emissions, pressure and others. The perfect packaging material should not transfer any harmful molecules from the packaging material into the product. To prevent damage to fish nugget products , it is necessary to implement hurdle technology. Hurdle technology is a concept of a combination of various preservatives and a scientific basis developed by Leistner, a researcher from Germany. Hurdle technology not only combines various preservation methods, but can also be used to optimize the desired curing effect without providing excessive curing treatment .

The combination of preservation carried out in this study was the use of sago flour, packaging with *polypropylene* (PP) plastic under vacuum conditions and storage at low temperatures. Sago flour has the advantage that it has a larger granule size and high amylose content, which causes a tendency to absorb water so that the characteristics become good and can reduce water activity thereby inhibiting the growth of microorganisms. PP plastic is used for packaging because this packaging has a high density that is resistant to temperature and humidity, and has low water absorption so that it can protect the *nugget* product . Vacuum conditioned so that air does not enter so that the product can last longer. Likewise, storage of products at low temperatures can inactivate microorganisms. Knowing how long fish *nugget* products can last, it is necessary to determine the shelf life as a form of food safety guarantee. In general, the shelf life of a product can be determined by the acceleration method (*Accelerated Storage Studies* , ASS or *Accelerated Shelf Life Testing* , ASLT). The ASLT method is very well used because of its relatively short testing time, high accuracy and precision.

The aim of this study was to obtain the most preferred formulation between rinuak fish with sago flour and pumpkin based on organoleptic tests and to determine the shelf life of rinuak fish *nuggets with* the most preferred formulation using the *arrhenius* method .

Manf aat from this study are Peng diversity of rinuak processed fish products that can be consumed by the public as well as increase the efficiency of fish rinuak, sago flour and pumpkin into value-added products through product *nugge t* fish rinuak . Packaging and storage conditions that can increase the lasting power and extend the shelf life of products *nugget* fish rinuak.

II. MATERIALS AND METHODS

This study was conducted at the Laboratory of Chemistry, Biochemistry Agricultural Products and Nutrition, Laboratory of Microbiology and Biotechnology of Agricultural Products Un iversitas Andalas Padang on the month in January until the month of March 202 1 . The raw material used in this study was rinuak fish obtained from fishermen in Jorong Muko-Muko Maninjau. The filler material in the form of sago flour was obtained from traders at the Rabaa Maninjau Market and pumpkin was obtained from traders in Matur while the additional ingredients were table salt, shallots, garlic, pepper, wheat flour, meizena flour, water, bread flour, and cooking oil. obtained from the Siteba Market, Padang City.

II.1 Stage 1 (One) Determining the Most Preferred Formula

Phase 1 research is to determine the most preferred formula in making rinuak fish *nuggets* . The results of this phase 1 research will support further research. The formula used included the percentage ratio between rinuak fish, sago flour and pumpkin. This study used a completely randomized design (CRD) with 3 treatments and 4 replications.

II.2 Stage 2 (Two) Estimating Product Shelf Life

Phase 2 research was carried out after obtaining the most preferred product formula from the research phase 1. After that, storage was carried out with product storage conditions, namely the product was packaged in Polypropylene (PP) plastic packaging under vacuum and stored at 0°C , -4°C and -15°C with an observation period of 30 days every 10 days and observations of water content, microbiology of rinuak fish *nuggets* , then calculations using the *Arrhenius* model .

III. RESULTS AND DISCUSSION

Step 1 Determining the Most Organoleptic Preferred Formulation

Organoleptic

Organoleptic assessment has an important role in the application of quality as it can provide an indication of spoilage and other damage to the product [4]. Organoleptic assessment with hedonic test is one type of acceptance test. In this test, the panelists were asked to express their personal responses about likes or dislikes [4].

Table 1. Percentage of Organoleptic Assessment of Rinuak Fish Nuggets

Treatment	Results				
	Texture (%)	Color (%)	Scent (%)	Taste (%)	Overall Admission (%)
A	82,80	81,52	20,00	91,80	88,20
B	83,40	81,74	51,40	93,00	90,60
C	85,80	81,98	60,00	94,20	93,80

Texture

Nugget with raw materials from a mixture of rinuak fish with sago flour and pumpkin has a compact and chewy texture, almost every treatment has the same texture. Texture has an important influence on the product for example from the level of compactness, surface, and hardness. Based on the data in Table 1, it can be seen that the most preferred texture by the panelists was the *nugget* texture in treatment C, with the percentage of panelists' preference level of 85.80%. Panelists tend to prefer a nice texture. Texture is a sensation of pressure that can be felt with the mouth (when bitten, chewed, and swallowed) or by palpation with the fingers [4].

Color

Color is a physical attribute that is assessed first in determining food quality and can sometimes be used as a measure to determine taste, texture, nutritional value and microbiological properties. Color affects the acceptance of a food ingredient, because generally the acceptance of the first material seen is color. Attractive colors will increase product acceptance.

The results of the organoleptic test for color in Table 1 show that the color most favored by the panelists was *nugget* with treatment C with a percentage of the panelists' preference rate of 81.98%. The color of the *nuggets* in each treatment has a color that is not much different. The overall color of the rinuak fish *nuggets* produced on the outside is gray and the outside is brownish yellow. This is because the color of the rinuak fish itself has a blackish color when it has gone through the cooking process.

Scent

The scent factor is also a determining factor for panelists' acceptance because a product even though it has good color or visual characteristics, but the scent is not distinctive and attractive will affect the interest of panelists [4].

Nuggets have a distinctive scent, which is a mixture of rinuak fish with sago flour and pumpkin. The scent factor is also a determining factor for panelists' acceptance because a product even though it has good color or visual characteristics, but the scent is not distinctive and attractive will affect panelists' interest [4]. Based on the data in Table 4, it can be seen that the most preferred scent by the panelists was the scent of nuggets in treatment C, with a percentage of the panelists' preference level of 60%. This scent is influenced by the distinctive smell of rinuak fish mixed with the distinctive smell of sago flour, but the distinctive smell of rinuak fish is more dominant because the percentage of rinuak fish is higher than the sago flour used.

Taste

The taste of food consists of three components, namely smell, taste, and oral stimulation [4]. Based on the data in Table 4 it can be seen that the taste of the most preferred by the panelists a da lah flavor nuggets in treatment C with the percentage of panelists preference level of 94.20%. Her rinuak more pronounced taste and distinctive smell strong rinuak in treatment C . R up to the nuggets are affected by material of fish raw rinuak, sago flour and pumpkin, additional material is also influential, such as the number of uses of sugar , salt, onion, pepper, and other ingredients in the composition of making nuggets, but in this study using the concentration of additives same . Nugget from a mixture of rinuak fish with sago flour has a distinctive taste, namely a mixture of the distinctive taste of rinuak fish and the distinctive taste of sago flour and pumpkin.

Overall Admission

Organoleptic assessment with hedonic test is one type of acceptance test. In this test, panelists were asked to express their personal responses about likes or dislikes, besides that they also expressed their level of liking or disliking. These levels of preference are referred to as hedonic scales, for example very much like, very like, like, somewhat like, neutral, somewhat dislike, dislike, very dislike and very dislike. These levels of preference are called hedonic scales [4].

The results of the overall acceptance by the panelists on the rinuak fish nugget product in the table shows that 87% of the researchers liked the C product (rinuak fish: sago flour: pumpkin = 70: 15: 15). The panelists' preference level was concluded from the soft and compact texture of the nuggets , the appropriate color, the distinctive scent of rinuak fish and other distinctive ingredients and the most preferred taste.

Phase II Estimation of Shelf Life

Determination of the shelf life of food products can be done by storing the product in actual storage conditions. One of the products whose shelf life is estimated is by measuring the rate of deterioration using the Arrhenius model .

Products nugget fish nuggets rinuak shelf life have made the determination after the most preferred product obtained from organoleptic, microbiological test and chemical test. The most preferred product was treatment C with the panelists' preference rate of 87%, the lowest amount of microbial contamination was produced in treatment C with an average colony number of 3.2 x 10^{3} colonies/g.The most preferred rinuak fish *nugget* product was then stored at 0°C, -4°C and -15°C for 30 days and the total plate count and water content were observed on days 0.10,20 and 30. The results of the study TPC changes and moisturecontent during storage are listed in table 2 .

Table 2. Average changes in ALT value and moisture content during storage

Storage Temperature 0°C		
Storage Time (Days)	ALT (colonies/g)	Water content (%)
0	3.4 x 10^4	53.67
10	4.5 x 10^4	49.23
20	3.5 x 10^4	45,16
30	2.7 x 10^4	43.85
Storage Temperature -4°C		
Storage Time (Days)	ALT (colonies/g)	Water content (%)
0	3.6 x 10^4	55.73
10	3.8 x 10^4	46.37
20	3.2 x 10^4	43.92
30	2.1 x 10^4	41.45
Storage Temperature -15°C		
Storage Time (Days)	ALT (colonies/g)	Water content (%)
0	3.2 x 10^4	52.86
10	7.6 x 10^3	28.54
20	4.2 x 10^3	24.65
30	1.2 x 10^3	20.32

Arrhenius Model Application

The microbiological quality in a food product is determined by the number and types of microorganisms present in the food. This microbiological quality will determine the shelf life of the product in terms of damage by microorganisms and the safety of the product from microorganisms is determined by the number of pathogenic species contained in the product. The results of the previous research showed a tendency to decrease product quality based on ALT and water content. Based on this trend, it can be ascertained that the selected rinuak fish nugget product used in this study will sooner or later experience a decrease in quality, damage and decay so that it is no longer suitable for consumption, therefore, it is necessary to estimate the shelf life of the product to estimate to what extent where can rinuak fish nugget products survive.

Each type of food has a limited shelf life depending on the type of food and storage conditions. In this study, to determine the shelf life of rinuak fish *nuggets* , calculations were carried out with reference to the *Arrhenius* shelf life determination model which involved storage at different temperatures. [5] stated that to analyze quality degradation, one of the important requirements that must be met is the existence of critical parameters that can be measured quantitatively. These critical parameters are usually specific depending on the characteristics of the product to be tested. One of the critical parameters that can be used for estimating the decline in quality of rinuak fish *nuggets* this time is ALT and water content.

Application Model *Arrhenius* At *Nugget* Fish Rinuak Based Microbiology Factor (ALT)

As shown in the table, it can be seen that there is a change in the ALT value in rinuak fish *nugget* products . Based on the average value obtained, then can be made a form of regression equation that shows the existence of a relationship between storage time to the value of ln ALT of the product at each different temperature.

Graph The linear regression equation for the average ALT of rinuak fish *nuggets* with each temperature can be seen in Figure 6. The equation of the linear regression curve is as follows:

1. Temperature 0°C : y = 3.8801 - 0.1789, r = 0.739, k 1 = - 0.1789
2. Temperature -4°C : y = 3.7818 - 0.0943 , r = 0.3393 , k 2 = - 0.0943
3. Temperature -15°C : y = 4.3886 - 1.0443 , r = 0.9782 , k 3 = - 1.0443

Determination of the value of k and T Value of quality degradation constant (k):

k1 = - 0.1789

k2 = - 0.0943

k3 = - 1.044

The absolute temperature value (T) (C+273) is:

T 1 (0°C) = 273 °K elvin

T 2 (-4°C) = 269 °K elvin

T 3 (-15°C) = 258 °K elvin

Drawing Plotting Value of ln k and 1/T value of ln k degradation (k)

ln k1 = ln - 0.1789 = - 2.3613

ln k2 = ln - 0.0943 = - 1.7209

ln k3 = ln - 1.0443 = 0.04335

1/T Value:

T1 = 1/T = 0.00366 = 36.6 x 10^{-4}

T2 = 1/T = 0.00372 = 37.2 x 10^{-4}

T3 = 1/T = 0.00388 = 38.8 x 10^{-4}

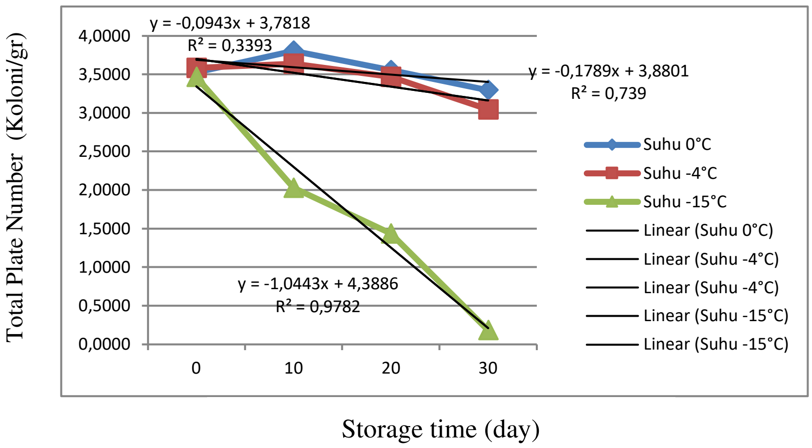

Figure 1. Graph of the Relationship of Storage Time to ALT Values at 0 °C, -4 °C and -15 °C temperatures.

1/T atau 1/K

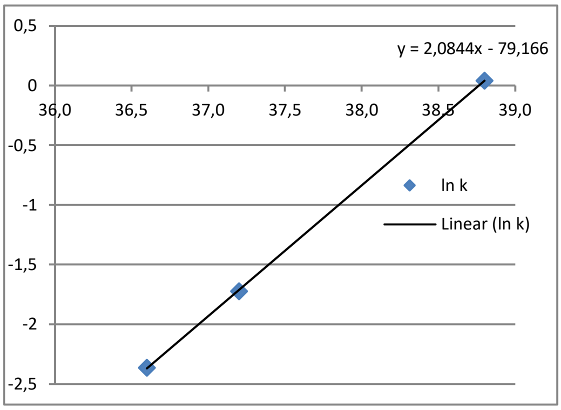

Figure 2. Graph of 1/T relationship to ln k ALT . value

Determination of the Mathematical Model The value of k is applied in the *arrhenius* formula , namely:

$$k = k_o . e^{-Ea/RT} \quad (1)$$

$$\ln k = \ln k_o - (Ea/RT) \quad (2)$$

Calculation of the graphic equation of the relationship between storage temperature (°K) and ln k at storage temperature, namely:

ln k = - 2.0844 + 79.166 (1/T)

Activation energy value (E):

-E/R = B

-E/R = 79.166

R = Gas Constant 1.986 cal mol $^{-1}$

So, E = 0.1572 cal mol $^{-1}$

Constant value does not depend on temperature (k_0):

$\ln k_0 = A$

$\ln k_0 = -2.0844$

$k_0 = 0.7344$

The model or equation for the rate of degradation of the ALT of rinuak fish *nuggets* is:

Temperature 0°C Suhu

$$k = k_o . e^{-Ea/RT}$$

$= 0.7344.e^{79.166 \times (1/T)}$

$= 0.7344.e^{79.166 \times (1/273+0)}$

$= 0.7344.e^{0.2899}$

$= 0.7344 . 1.3364$

$= 0.9815$

Temperature -4°C

$$k = k_o . e^{-Ea/RT}$$

$= 0.7344.e^{79.166 \text{ x } (1/T)}$

$= 0.7344.e^{79.166 \text{ x } (1/273+(-4))}$

$= 0.7344.e^{0.29430}$

$= 0.7344 \;.\; 1.3422$

$= 0.9857$

Temperature -15°C

$$k = k_o . e^{-Ea/RT}$$

$= 0.7344.e^{79.166 \text{ x } (1/T)}$

$= 0.7344.e^{79.166 \text{ x } (1/273+(-15))}$

$= 0.7344.e^{0.30684}$

$= 0.7344 \;.\; 1.3591$

$= 0.9981$

So the rate of decline in the quality of rinuak fish *nuggets* based on changes in ALT for a temperature of 0°C is 0.9815, a temperature of -4°C is 0.9857 and a temperature of -15°C is 0.9981 per day. The initial and final quality limits of the product are obtained from the average amount of ALT obtained during storage (table 2)

Calculation of shelf life (t)

$$t = (A_o - A_t)/k$$

Shelf life (t) at 0°C $= \frac{34-27}{0{,}9815}$ = 7 days

Shelf life (t) at -4°C $= \frac{36-21}{0{,}9857}$ = 15 days

Shelf life (t) at -15°C $= \frac{34-12}{0{,}9981}$ = 31 days

Based on the regression graph (figure 1), the value of ln ALT for both products stored at 0°C, -4°C and -15°C, all showed a linearity pattern.

Based on the calculation results, the shelf life of rinuak fish *nuggets* at a temperature of 0°C is 7 days, a temperature of -4°C is 15 days, while for a temperature of -15°C is 31 days. A decrease in temperature will reduce the potential energy of a substance so that it slows down the collision between the molecules of the substance (microbial growth), which is effective in starting the reaction. In rinuak fish *nugget* product , the collisions of substance molecules at cold temperatures (0°C and -4°C) are faster than those at freezing temperatures (-15°C) so that the rate of deterioration is also faster and causes a shorter shelf life.

Application Model *Arrhenius* At *Nugget* Fish Rinuak Based Moisture Factor

As shown in the table, it can be seen that there is a change in the water content of the rinuak fish *nugget* product . Based on the average value obtained, then can be made a form of regression equation that shows the existence of a relationship between the length of storage to the value of ln product moisture content at each different temperature.

Graph The linear regression equation for the average water content of rinuak *nugget* with each temperature can be seen in Figure 1. The equation for the linear regression curve is as follows:

1. Temperature 0°C : y = 4.0407 - 0.0693 , r = 0.9611 , k1 = - 0.0693
2. Temperature of -4 ° C : y = 4.0766 - 0.0942 , r = 0.9014 , k2 = - 0, 0942

3. Temperature -15°C : y = 4.1375 - 0.3015 , r = 0.8866 , k3 = - 0.3015

Determination of the value of k and T Value of quality degradation constant (k):

k1 = - 0.0693

k2 = - 0.0942

k3 = - 0.3015

The absolute temperature value (T) (C+273) is:

T 1 (0°C) = 273 °K elvin

T 2 (-4°C) = 269 °K elvin

T 3 (-15°C) = 258 °K elvin

Drawing Plotting Value of ln k and 1/T value of ln k degradation (k)

ln k1 = ln - 0.0693 = - 2.6693

ln k2 = ln - 0.0942 = - 2.3623

ln k3 = ln - 0.3015 = - 1.1990

1/T Value:

T1 = 1/T = 0.00366 = 36.6 x 10^{-4}

T2 = 1/T = 0.00372 = 37.2 x 10^{-4}

T3 = 1/T = 0.00388 = 38.8 x 10^{-4}

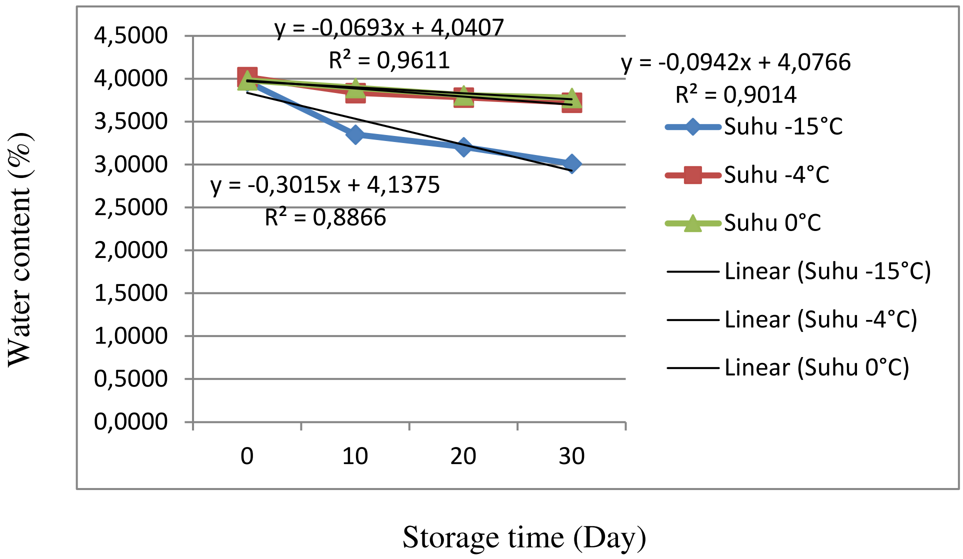

Figure 8. Graph of the Relationship of Storage Time to the Value of Water Content at 0 °C, -4 °C and -15 °C temperatures.

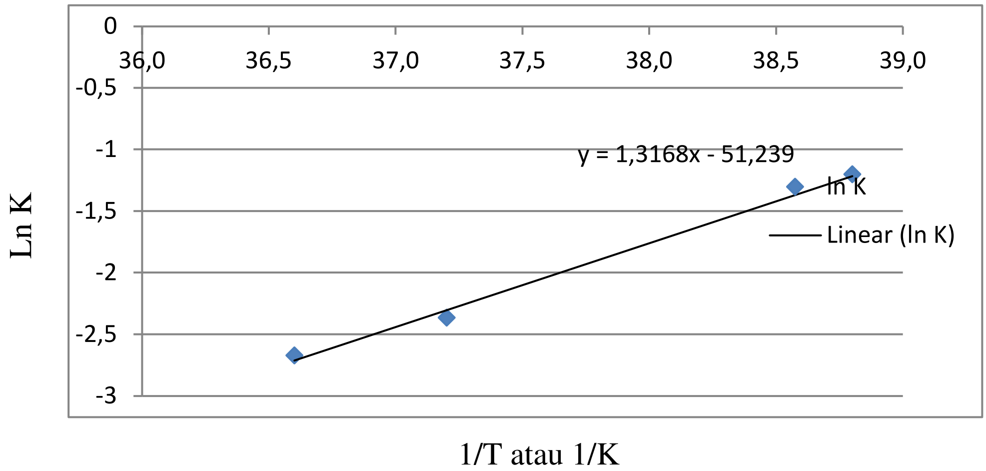

Figure 9. Graph of 1/T relationship to ln percentage of moisture content

Determination of the Mathematical Model The value of k is applied in the *arrhenius* formula , namely:

Calculation of the graphic equation of the relationship between storage temperature (°K) and ln k at storage temperature, namely:

$$k = k_o . e^{-Ea/RT} \quad (1)$$

$$\ln k = \ln k_o - (Ea/RT) \quad (2)$$

ln k = - 1.3168 + 51.239 (1/T)

Activation energy value (E):

-E/R = B

-E/R = 51.239

R = Gas Constant 1.986 cal mol $^{-1}$

So, E = 0.1017 cal mol $^{-1}$

Constant value does not depend on temperature (k_0):

ln k_0 = A

ln k_0 = - 1.3168

k_0 = 0.2752

The model or equation for the rate of deterioration of the water content of rinuak fish *nuggets* is:

Temperature 0°C Suhu

$$k = k_o . e^{-Ea/RT}$$

= 0.2752.e $^{51,239 \times (1/T)}$

= 0.2752.e $^{51,239x\ (1/273+0)}$

= 0.2752.e $^{0.1877}$

= 0.2752 . 1.2065

= 0.3320

Temperature -4°C

$$k = k_o . e^{-Ea/RT}$$

$= 0.2752.e^{51,239x\ (1/T)}$

$= 0.2752.e^{51,239\ x\ (1/273+(-4))}$

$= 0.2752.e^{0.1905}$

$= 0.2752\ .\ 1.2098$

$= 0.3330$

2. Temperature -15°C

$$k = k_o . e^{-Ea/RT}$$

$= 0.2752.e^{51,239\ x\ (1/T)}$

$= 0.2752.e^{51,239\ x\ (1/273+(-15))}$

$= 0.2752.e^{0.1866}$

$= 0.2752\ .\ 1.2197$

$= 0.3357$

So the rate of decline in the quality of rinuak fish *nuggets* based on changes in water content for a temperature of 0°C is 0.3320, a temperature of -4°C is 0.3330 and a temperature of -15°C is 0.3357 per day. The initial and final quality limits of the product are obtained from the average amount of water content obtained during storage can be seen in table 14

Calculation of shelf life (t):

$$t = (A_o - A_t)/k$$

Shelf life (t) at 0°C $= \frac{53,67-43,85}{0,3320} = 30$ days

Shelf life (t) at -4°C $= \frac{55,73-42,45}{0,3330} = 43$ days

Shelf life (t) at -15°C $= \frac{52,86-20,32}{0,3357} = 97$ days

In general, it is seen that there is a decrease in the percentage of product moisture content along with the length of storage time, both for products stored at cold temperatures of 0°C, -4°C and frozen temperatures of -15°C .

Based on the regression graph (figure 16), the value of ln moisture content in both products stored at temperatures of 0°C, -4°C and -15°C, all showed a linearity pattern.

Based on the calculation results, the shelf life of rinuak fish *nuggets* at a temperature of 0°C is 30 days, -4°C is 43 days, while for a temperature of -15°C is 97 days. From the observation of the water content at the three temperatures and storage time, it was found that the water content was lower during storage. *Nuggets* release a lot of water to reach equilibrium and adjust to changes in temperature and humidity. that vacuum packaging is more effective in reducing the rate of increase in water content during storage because in vacuum treatment all water vapor and air in the packaging have been sucked out of the packaging first.

Kusnandar [6] suggests that water has an important role in the food system, namely: (1) affecting the freshness, stability and durability of food, (2) acting as a universal solvent for ionic and polar compounds, such as salt, vitamins, sugars and pigments. , (3) play a role in the polymerization reaction of the formation of carbohydrates, proteins and fats, (4) affect enzyme activity, (5) important factor for microbial growth, (6) determine the level of food safety risk and (7) as a medium to transfer water safety risk levels in the food system.

IV. CONCLUSIONS

The most preferred formula for making rinuak fish *nuggets by* panelists is formula C where the ratio of rinuak fish: sago flour: pumpkin is 70%: 15%: 15% = 70%: 15%: 15%) . Rinuak fish *nuggets* made with formula C had a shelf life of 31 days at a temperature of -15°C judged by the number of microbes and had a shelf life of 43 days at a temperature of -15°C judged by the amount of water content and still in accordance with the established standards.

REFERENCES

[1] Periwaldi, R. 2012. Morphological Study of Badr Fish in Lake Siais, North Sumatra and Rinuak Fish in Lake Maninjau, West Sumatra . Faculty of Mathematics and Natural Sciences. Andalas University. field.

[2] Adawyah, R. 2008. Fish Processing and Preservation. PT Bumi Aksara. Jakarta.

[3] Nurhidayati. 2011. Contribution of Mp-Asi Baby Biscuits with Substitution of Pumpkin Flour (Cucurbita Moschata) and Catfish Flour (Pangasius 47 Spp) on Protein and Vitamin A Adequacy. Diponegoro University. Semarang.

[4] Soekarto, ST. 2012. Organoleptic Test of Nutrient Rich Cookies Formulation. Depok: University of Indonesia

[5] Syarif, R. Dan Halid, H. 1993. Food Storage Technology. Arcan Publisher. Jakarta. Cooperation with the Center for Inter-University and Nutrition IPB. Bogor

[6] Kusnandar, F. 2001. Experimental Design in Determining the Shelf Life of Food Products with ASLT Method (*Arrhenius* Model and Critical Moisture Content). Bogor Agricultural Institute.