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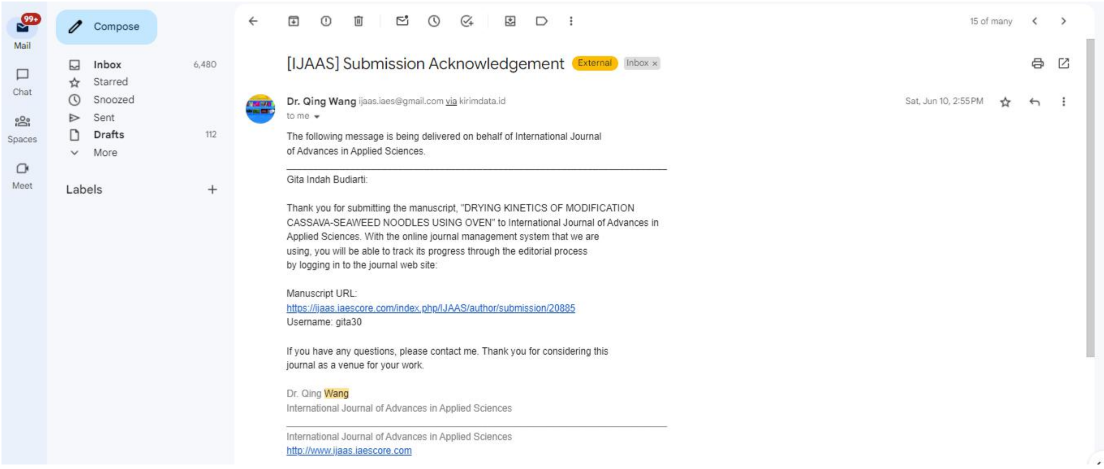

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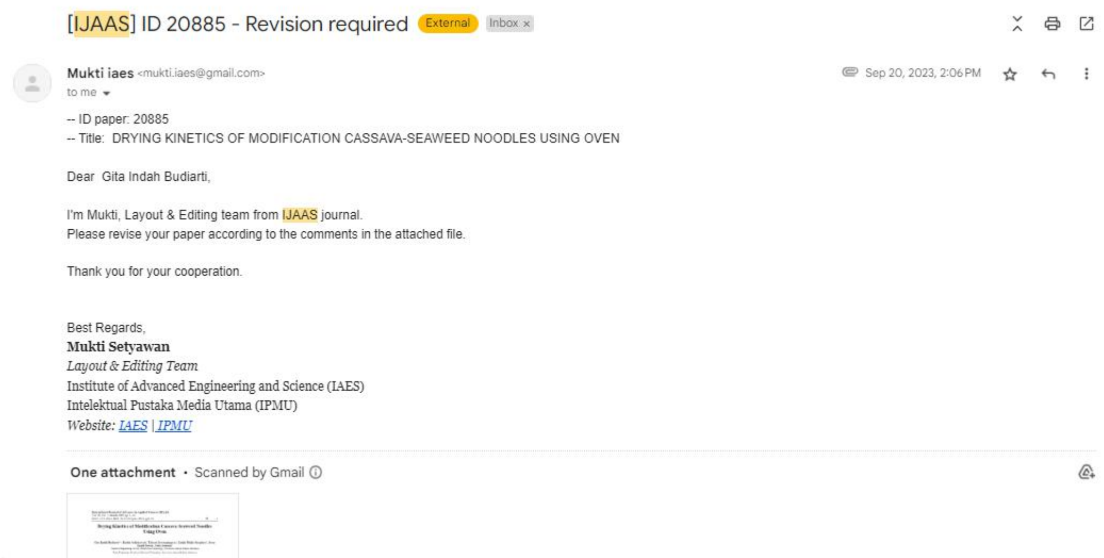

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- Authors examine the use of lowercase letters, uppercase letters, and the use of symbols in this article, such as Section B.3.3 (….. the (M)oisture ratio…..) or Eq. 4 (K and k).
- Please check the variable unit in Eq. 3, left-hand units are not equal to right-hand ones ($m^2=m^3+m^2$).
- Authors check the unit of the parameter. For example, K (or k) is a parameter with units (1/h) or without units?
- Is the L parameter in Eqs. 2 and 3, and Eqs 7, 8 and 9 the same? If yes, check the units, if not, define the value of L.

Question/Recommend

- From Fig. 1, what is the initial moisture content of the sample? Is the initial moisture content the same?
- The author should specify the final moisture content or standard moisture content (SNI Standard (SNI 8217: 2015)). Analyzing various estimates(such as: ash content, total protein, lipid carbohydrates and drying parameter (k, Deff)), the authors should study within the extent that the samples are of good quality.
- The author should specify initial moisture content, final moisture content. and drying time at each drying temperature.
- - Fig. 2, the author plots the linear relationship between MR and t to describe the Newton model. Then, the constant from the graph was calculated the k value in Eq. (3). The author should explain the data acquisition in the graph and how k is calculated. In general, MR(t=0 h)=1 and decreases as moisture content, but Fig. 2 tends to increase, explain.
- From Fig. 1, moisture content at 60°C decreases slower than 70°C but k value is higher, what happened? The author checks the information.
- Please, to check the trend of k value in table 1. The increasing drying temperature increase the k value and drying rate, but the results in this article decrease. What happen? Explain.

- General drying kinetic articles, Newton model is a good model and high R^2, but in this article R^2 are low all drying temperatures. What happen of results, explain.
- Fig. 3, the author plots the linear relationship between ln (MR) and t to determine Deff from Eq. (9). At t=0 h, MR=1 =>ln MR=0, the trend of graph decreases with t. Explain.
- Table 2 shows Deff, found that at 70°C it was much higher than at 60°C, while the decrease in moisture content was similar. The experimental results should be explained. At 80 and 90°C, the moisture content is reduced faster than at 70°C, but the Deff is lower. Why? Explain?
- R^2 value in table 2 for 60, 80 and 90 are very low. Author check the data and method to determine the Deff.
- Table 3, The authors specify the drying conditions for the analysis of the Proximate test.

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Drying Kinetics of Modification Cassava-Seaweed Noodles Using Oven

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ABSTRACT

Consumption of noodles in the world is always increasing. Noodles made from wheat flour are unhealthy, because they cause diabetes, so alternative noodles are needed, such as modification cassava flour and seaweed. Modification cassava is used because it does not contain gluten and seaweed has nutritional value to make healthy, low-calorie noodles. The purpose of this study was to determine the temperature and time of the drying parameters of seaweed noodles. The drying method uses an oven with variable temperature (60, 70, 80, 90°C) and drying time (2,4, 6, 8 and 10 hours). The results of the study obtained optimal water content at 60 °C with 6 hours of 11.75%. The drying kinetic evaluated by Logaritmic Equation, optimal drying constant value at 80 °C of 0.67 h-1 with R^2 0,9391. Effective moisture diffusivity (D_{eff}) maximum evaluated by second Fick Law obtained 9.35 x 10^7 m^2/ sec at temperature 90ºC with R^2=0.9227. The proximate value of ash content is 12.11%, protein is 9.46%, lipid is 0.10% and carbohydrates is 65.08%.

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1. INTRODUCTION

Noodles are one of the most widely consumed types of food by all people in the world. In this era of modernization, there have been many changes in human behavior in fulfilling their wants and needs. Increased activity from the bustle of society, causing people to need a product that is practical to consume when served. Community mobility has caused people to no longer use rice as the main source of carbohydrates, but instant noodles which are practically the main source of carbohydrates.

World Instant Noodles Association (WINA), instant noodle consumption in Indonesia is 13.27 billion servings in 2021. This number is the second largest after China/Hong Kong with instant noodle consumption of 43.99 billion servings in 2021, Vietnam is in third place with instant noodle consumption of 8.56 billion servings. Then, consumption of instant noodles in India amounted to 7.56 billion servings. Consumption of instant noodles in Japan was recorded at 5.85 billion servings. Meanwhile, consumption of instant noodles in the United States was reported at 4.98 billion servings. The Philippines is a country that consumes a lot of instant noodles, reaching 4.44 billion servings. Meanwhile, South Korea is in eighth position with instant noodle consumption of 3.79 billion servings [1], [2].

Wheat flour is the main raw material for making noodles. Wheat flour contains gluten which can increase blood sugar levels, causing various diseases if consumed in excess. Modified cassava flour can be used as an alternative to wheat flour. Modified Cassava Flour is flour made from 100% cassava which is soaked using organic enzymes or through a fermentation process with enzymes without additives and produces gluten-free flour. The addition of seaweed will further add to the nutritional content of the resulting noodles. Seaweed is useful as an antioxidant, anti-inflammatory, anti-diabetic and anti-cancer [3]. The advantage of seaweed in terms of processing is that it is very easy and simple to do on a household scale. The benefits of consuming seaweed are: a source of nutrition, diet, improving digestion, healing wounds, minimizing cancer cells, skin detox, and preventing premature aging, while the disadvantages of seaweed itself are: contact dermatitis, digestive tract disorders, goiter, cholera and inflammation . The Indonesian National Standard for seaweed 8169:2015 defines seaweed as dried seaweed that has been refined.

The process of making noodles includes making noodle dough and drying it. The process of drying noodles can be done using various methods [4], including traditional drying using the sun [5], [6], frying and roasting using an oven. Baking with an oven is considered healthier and more hygienic.

Several studies on making noodles have been carried out, including making noodles using rice flour as raw material [7]. Noodle made from orange sweet potato [8], Bambara wheat protein [9]. Previous studies have discussed the characteristics, physicochemical properties [10] and nutritional content of noodles, there has been no discussion regarding the drying kinetic of modification cassava-seaweed noodles. The drying process of noodles is interesting to study because it determines the durability and quality parameters of noodles such as nutritional content.

2. RESEARCH METHOD (10 PT)

2.1. Noodle Making

The manufacture of dry noodles begins with making 100 grams of seaweed gel which has been made into a gel. then for the flour composition for each dough, namely modification cassava flour: 10 gram flour: 140 gram; 20 grams : 130 grams; 30 grams : 120 grams; 40 grams : 110 grams and 50 grams : 100 grams, as well as the addition of additional noodle ingredients, namely: 2% salt, and 1% CMC from the weight of the noodles which have been mixed with the basic ingredients of 250 grams and divided into 4 parts as much as 50 grams of the flour weight which is put into the dough and stirred until smooth. The smooth dough was left for 10 minutes and then printed with a weight of 50 grams. .

2.2. Drying

Noodles were dried with a long drying time using an oven consisting of four levels: 2 hours (L1); 4 hours (L2); 6 hours (L3); 8 hours (L4) and 10 hours (L5), for drying temperature (S) consisting of four levels: 60°C (S); 70°C (S2); 80°C (S3); and 90°C (S4). The dried noodles are then stored in a closed place.

3. Analysis

3.1. Calculation of Water Content

Noodles are dried at 60℃ (S1); 70℃(S2); 80℃ (S3); and 90℃ (S4), until constant noodle weight. 2 hour intervals (L1); 4 hours (L2); 6 hours (L3); 8 hours (L4) and 10 hours (L5) using the oven. The noodles were weighed to determine the weight loss of the ingredients. The decrease in water content is calculated by the formula [11]:

$$\text{moisture content } \% = \frac{(\text{Initial weight} - \text{final weight})}{\text{initial weight}} \text{ x } 100\% \ldots\ldots (1)$$

3.2. Noodle Surface Area Calculation

Dry noodles that will be formed in the form of cubes and long blocks with the formula used are:

1. Cube

$$L = s \text{ x } s \ldots\ldots(2)$$

Information:

L : Surface area of dry noodles (m^2)

s : square side of dry noodles (m)

2. Blocks

L = 2 x((p x l)+(p x t) +(l x t))……………………………………….(3)

Information:

L : Surface area of dry noodles (m^2)

p : Length of dry noodle surface (m)

l : Width of noodle surface (m)

t : height of noodle surface (m)

3.3. Calculation of Drying Kinetic Constants

Several conventional drying models have been proposed to determine the Moisture ratio as a function of time. In this study the Logaritmic model was used [11]:

M_R=A(exp –kt)+B…………………………………….(4)

Information:
M_R = Moisture ratio
k = Constanta (1/h)
t = Time (h)
A,B=konstanta
Moisture ratio (M_R) formula:

$$M_R = \frac{M_t - M_e}{M_i - M_e} \quad \text{……………………………………………………………….(5)}$$

According to Diamante and Munro (1993) in [11] the equilibrium moisture content (M_E) is relatively small compared to the initial moisture content (M_I), especially for far infrared drying. So that the moisture ratio (M_R) can be simplified to M_T/M_I.

3.4. Calculation of the Diffusivity Coefficient of Solids (D_{eff})

In drying, diffusivity is used to indicate the flow of the water content of the material. In the falling rate period, the reduction in water content is controlled mainly by molecular diffusion. The effective diffusivity coefficient is determined by adjusting the mathematical model for fluid diffusion according to the Second Fick Law (Equation 6 to Equation 9) assuming the geometric shape is a slab, the water content only migrates by diffusion, ignoring volumetric shrinkage, constant temperature, and long drying time. For long drying times, Equation (7) can be simplified into Equation (8) where this equation can be rearranged into Equation (9). From Equation (9), plotting in a graph of value (ln M_R) versus time will produce a straight line with slope [11].

$$\frac{\partial M}{\partial t} = M.\nabla^2.D_{eff.} \text{ ....(6)}$$

$$M_R = \frac{8}{\pi^2}\sum_{n=0}^{\infty}\frac{1}{(2n+1)}\exp\left(-\frac{(2n+1)^2\pi^2 D_{eff}.t}{4L^2}\right)\text{…………………………………(7)}$$

$$M_R = \frac{8}{\pi^2}\exp\left(-\frac{\pi^2 D_{eff}.t}{4L^2}\right)\text{………………………………………………….(8)}$$

$$ln\,M_R = ln\frac{8}{\pi^2} - \left(\frac{\pi^2 D_{eff}}{4L^2}\right)t\text{………………………………………………....(9)}$$

3.5. Proximate Analysis

Proximate analysis classifies food ingredients according to chemical composition, namely: total water content, total ash content, total crude protein content, total crude fat content [12]. Proximate analysis, as a general method for determining the chemical composition of food ingredients, does not require sophisticated testing techniques, provides rough analysis results, can calculate the total digestible nutrient value. Total Digestible Nutrient (TDN) has several advantages, such as providing a general rating for food. Food use. Proximate analysis also has several drawbacks, such as the inability to accurately produce the concentrations of chemical compositions and the inability to calculate the digestibility and texture of food components.

3. RESULTS AND DISCUSSION (10 PT)

A. Moisture Content

Determination of water content in dry noodles by drying method using an oven within 2 hours, 4 hours, 6 hours, 8 hours, 10 hours, and temperature 60°C, 70°C, 80°C, 90°C is presented in Table 1.

Table 1. Moisture Content in Noodles Drying Using an Oven

Time (h)	**Temperature (°C)**				**Standar**
	60	**70**	**80**	**90**	
2	24.61	24.08	12.94	17.25	8-13%
4	13.33	11.86	10.42	6.11	
6	11.75	12.43	5.73	8.95	
8	7.56	6.81	2.98	2.32	
10	6.04	4.58	0.75	0.78	

Based on Table 1, the results of the analysis of the water content of dry noodles obtained an average moisture content ranging from 11.75% - 13.33% from a temperature of 60 °C at 4 hours and 6 hours, then at a temperature of 70 °C the results obtained a water content of 11.86-12.43% of the 4h and 6h time. Then the temperature of 80 °C resulted in a moisture content of 12.94% - 10.42% for 2 hours and 4 hours. For a temperature of 90 °C, the water content requirements at 6h (8.95%) are met according to SNI 8217: 2015 concerning the moisture content of dry noodles, namely 8% - 13%. So it can be concluded that the water content at drying temperature is 60 °C and 70 °C at 4 hours and 6 hours, the temperature is 80 °C at 2 hours and 4 hours , the tmperature 90 °C at 6 h which fulfills the water content requirements according to SNI 8217:2015, namely 8%-13%. Because in general, the greater the difference between the drying medium and the food, the faster the heat transfer to the food and the faster the evaporation of water from the food, so high-temperature air takes water from food more quickly so that the drying process is faster [13].

Previous research, drying white noodles with temperature 50ºC using zeolite result 13.7% moisture content within 90 minutes [4]. In this research, within 2 hours (120 minutes) without zeolite at temperature 60 ºC can provide moisture content average 19%. Research by Engelen *et al.*, (2015) [14] making dry noodles from modification cassava and starch, moisture content range 7.35-9.81% at 4 hours and temperature 105 ºC. This research at 4 hours and temperature 90 ºC can obtained moisture content 6.11%. The higher temperature can broke nutrition in noodles.

The factors that affect the decrease in the moisture content of dry noodles are: temperature and humidity in the oven, temperature and air pressure in the oven chamber, the size and structure of the noodle particles, and the shape of the noodle container [5], [15].

B. Drying Kinetics

Moisture ratio (M_R) MR can be calculated by comparison of MI and MT. MI and MT data can be seen in Table 2. The drying constant (k) value using the moisture ratio (M_R) at 60°C can be obtained graphically in Figure 1.

Table 2. Data Moisture Initial and Final at Various Temprature

Time (h)	Temperature (°C)							
	60		70		80		90	
	MI	MT	MI	MT	MI	MT	MI	MT
2	0.32	0.25	0.33	0.24	0.22	0.13	0.27	0.17
4	0.31	0.13	0.31	0.12	0.32	0.10	0.35	0.06

6	0.30	0.12	0.32	0.12	0.27	0.06	0.43	0.09
8	0.34	0.08	0.34	0.07	0.31	0.03	0.37	0.02
10	0.34	0.06	0.35	0.05	0.35	0.01	0.40	0.01

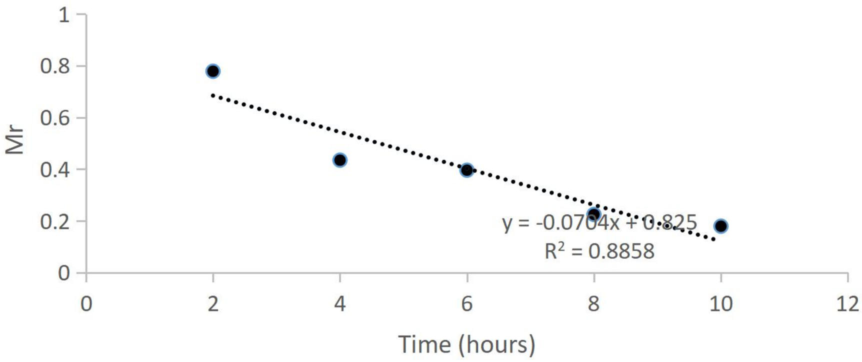

Figure 1. Moisture Ratio Experiment Data and Model Logaritmic Equipment

Based on the graphical results of the drying kinetics and the constants in Figure 1, the effective diffusivity coefficient at 60°C is obtained by the value of R^2 (Coefficient of Determination) = 0.8858 While the equation of the line y = -0.0704x+0.825. From the linear equation, the value of k is -1.11 h^{-1}. By means of the same calculation, Table 3 is obtained:

Table 3. Constanta Drying Kinetic value by Logaritmic Equation

Temperature (°C)	Constanta (k) (h^{-1})	R^2	Logaritmic's Equation
60	-1.11	0.8858	M_R =A exp (1.11 t)+B
70	-1.03	0.8837	M_R =A exp (1.03 t)+B
80	-0.69	0.9391	M_R =A exp (0.69 t)+B
90	#NUM	0.7531	-

Based on Table 3 constant values and Logaritmic Model Parameters above, the results of constant values, M_R values, and R^2 (Coefficient of Determination) values and it can be seen that at each temperature the k value increase, this identifies the magnitude of the decrease in water content at the beginning of drying due to the high free water content in the material that moves to the surface and undergoes evaporation. However, the longer the time, the greater the effect on decreasing the drying rate. This is because what remains is bound water which is difficult to diffuse to the surface. The value of k will also affect the quality of the product that has been dried, because there are various accompanying phenomena, including heat transfer and reduced size due to reduced moisture content [11].

The optimum k value in this study using the Logaritmic method was produced at a temperature of 80 °C of -0.69 h^{-1} with R^2 0.9391. In research conducted by Suprapti (2019) [16] drying noodles with corn and wheat flour at 70°C has k value of 0.1218, which is faster than other temperatures.

B. Effective Moisture Diffusivity

Several conventional drying models have been proposed to determine the Moisture ratio (M_R) relationship as a function of the characteristic drying time of the noodles, for each initial moisture content

(M_I) the initial weight is 50 grams. The calculation of effective moisture diffusivity (D_{eff}) describes the migration or diffusion of water in dry noodle products during drying operations which is a function of water content, temperature, and material structure. The effective moisture diffusivity value for a temperature of 60°C can be obtained from Figure 2.

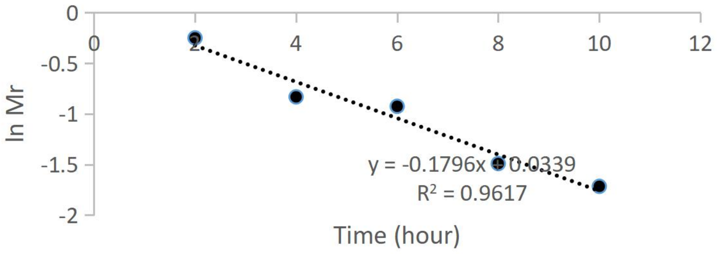

Figure 2. Effective Moisture Diffusivity

Based on Figure 2. D_{eff} value at 60°C was obtained by substituting equations (8) and (9) with the linear algebraic equations on the graph obtained, resulting in a D_{eff} value of 4.20 m²/second. The R^2 value generated in graph 2 is 0.9617.

Using the same calculation method, data obtained from the results of the Deff value and the R^2 value for other temperature showed on Table 4.

Table 4. Effective Moisture Diffusivity at Various Temperature

Temperature(°C)	D_{eff} x10^7(m^2/sec)	R^2
60	4.20	0.9617
70	4.77	0.9507
80	9.17	0.9381
90	9.35	0.9227

Based on Table 4, it shows that the higher the D_{eff} value obtained, the greater the drying speed resulting from the drying process of dry modification cassava seaweed noodles. Factors that influence the results of the Deff value at each temperature are: temperature and humidity in the oven, temperature and air pressure in the oven chamber, the size and structure of the noodle particles, and the shape of the noodle container.

Proximate Analysis

Seaweed dry noodles made from modification cassava flour with wheat flour which has been made into dry noodle products. Furthermore, it is analyzed based on analysis including the proximate test. The proximate test is a method of chemical analysis to identify the nutritional content such as protein, carbohydrates, fats and fiber in a food substance from feed or food ingredients. Samples with optimum moisture content, namely at 60°C, drying for 4 hours were used for the proximate test. This is because the temperature of 60°C is still a safe range for drying food ingredients, and the water content obtained is in accordance with SNI standards. The results of the dry noodle proximate test can be seen in Table 5.

Table 5. Proximate Test Results on Dry Noodles

Parameter	Result	Standard
Ash content (%wb)	12.11	3%[a]

Total Protein, Fk = 6.25 (%wb)	9.46	$8 - 10\%^{a}$
Lipid (% wb)	0.10	$11{,}8\%^{b}$
Carbohydrates (%wb)	65.08	$50\%^{b}$

*notes : a : SNI Standard (SNI 8217: 2015)

b : nutrition food standard (Kementrian Kesehatan RI, 2014)

Based on the proximate test results of dried seaweed noodles made from modification cassava flour and wheat flour, for the analysis of dry noodle. Analysis of the ash content according to SNI for the maximum quality of dry noodles is 3% in this study, the ash content of dried seaweed noodles made from modification cassava flour and wheat flour is 12.11%. According to Endang, 2019, the results of the ash content obtained were 1.78%. These results indicate that the results of the analysis of ash content in this study are greater than the Indonesian National Standard No. 01-2974-1996. Seaweed dry noodles made from modification cassava flour and wheat flour are noodles that do not meet the quality of the results of the analysis of ash content.

Furthermore, for analysis of total protein content according to SNI, the quality of dry noodles is at least 8% of the results obtained for seaweed noodles made from modification cassava flour and wheat flour of 9.46%. According to Endang.2019, the results of the analysis of protein levels obtained were 10.7232%. Thus the protein content produced in this study meets the value of SNI 8217: 2015. Therefore, it was found that noodles made from modification cassava flour and wheat flour were noodles with quality that met the analysis of total protein content.

For analysis of the fat content, the value produced for seaweed noodles made from modification cassava flour and wheat flour is 11.8%, while it is known that the fat content in dry noodles is 0.03% . Thus the fat content produced in this study meets the nutritional value of 2022. Therefore, the noodles made from modification cassava flour and wheat flour are noodles with nutritional value quality that meets the fat content. Previous research from Ismail, Law and Hii, (2016) [17] reported that treatment drying can decrease fat content.

Furthermore, for the analysis of the carbohydrate content obtained in seaweed noodles made from modification cassava flour and wheat flour of 65.08%, while it is known that the carbohydrate value of the total energy consumption is 77.73-77.04% [18]. Based on the nutritional value results for 2022, 50% is produced in carbohydrates for dry noodles.

Previous research reported that treatment or substitution noodles can affected protein, lipid/ fat decrease, meanwhile ash content and carbohydrate increase. The result can be attributed to the absorption of moisture during noodle drying, a phase in noodle processing which helped to trap water in the noddle structure. It is also interesting to note that there is an increase in ash content with increase in inclusion of the protein isolates. This may be as a result of high mineral content especially the macro mineral present in modification cassava-seaweed isolate [4], [9], [19],[20]–[25].

4. CONCLUSION

Based on research on dry seaweed noodles from modification cassava flour and wheat flour, it can be concluded that temperature and time affect a decrease in water content, drying speed, and drying constant. Optimal water content analysis results at 60 °C at 6 hours of 11.75%. The drying kinetic evaluated by Logaritmic Equation, optimal drying constant value at 80 °C was of -0.69 h-1 with R2 0.9391. Effective moisture diffusivity (Deff) maximum evaluated by second Fick Law obtained 9.35 x 107 m2/ sec at temperature 80ºC with R2=0.9227. The proximate value of ash content is 12.11%, protein is 9.46%, lipid is 0.10% and carbohydrates is 65.08%.

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REFERENCES (10 PT)

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