Shelf Life Determination of Pegagan (*Centella asiatica*) Chips Using Accelerated Shelf-Life Testing (ASLT) Method

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Abstract

Pegagan (Centella asiatica) is a wild plant with various kinds of efficacies for health and usually as herbal or traditional medicine. Pegagan has been processed into various new products including chips. Pegagan Chips are hygroscopic product that easy to absorb water from the environment. The objective of this study was to determine the shelf life of Pegagan Chips packed in different type of packaging materials. The shelf life of Pegagan Chips was determined using Accelerated Shelf-Life Testing (ASLT) method with a critical moisture content approach. Two different types of packaging used were polyethylene (PE) plastic and standing pouch aluminum foil. The samples were stored at 28°C and RH 75%. The results showed that the shelf life of Pegagan Chips with PE plastic and aluminum foil standing pouch were 83 and 139 days, respectively. Aluminum foil standing pouch possessed lower packaging permeability which was 0.0603 g/m2.day.mmHg compared to PE plastic.

Keywords: *Aluminium foil, ASLT, Chips, Pegagan, Polyethylene, Polypropylene, Shelf life.*

1. INTRODUCTION

Pegagan (Centella asiatica) is a plant that spread widely in tropical and subtropical areas. This plant belongs to a group of wild plants that thrives in the open environment and prefer a rather humid place such as fields, gardens, or on the roadsides. Pegagan Leaf believed to have efficacy for health. Properties of pegagan improve brain tissue that regulate the interaction so that it can be given to people with mental fatigue, insomnia, stress, and to sharpen memory. According (Sutardi, 2016) the content of asiatikosida in Pegagan plant can improve memory and resolve senile. In addition to asiatikosida, Centella asiatica also contains tannins, essential oils, sitosterols consisting of glycerides, oleic acid, linoleic, palmitate, stearate, sentoat and sentelat useful to improve the body's immune system. Pegagan plants contain madecoside glycoside compounds in the leaves and petiole and they have anti-inflammatory and anticoid effects.

Centella asiatica is usually consumed as a traditional medicine or herbal medicine and the last few time it is processed into pegagan chips. Pegagan chips is a processed food made from Pegagan leaves made with chips dipped rice flour dough and spices then fried to dry. Pegagan chips made with spices like chips in general. Pegagan chips as one of the processed foods from agricultural products have the nature of easily damaged the loss of crispness due to the entry of water vapor from the environment if not handled properly. Handling can be done that is by packing chips to maintain quality and shelf life. Theoretically, shelf life is the time period from which food products are produced until the product is not proper for consumption. A product to be in its shelf life range if the product quality is generally acceptable for the intended purpose of the consumer and as long as the packaging material still has integrity and protects the packaging contents (Taufik, 2014). Various packaging with various characteristics can be used to pack the chips. The packaging has different moisture permeability values that affect the quality of the chips during storage and shelf life of the product. Permeability is the transfer of gas and vapor in the polymer by diffusion mechanism.

In addition to polyethylene plastic packaging, pegagan chips can be packed with modern packaging that is easily obtainable on the market such as standing pouch PP and standing pouch aluminum foil. Different types of packaging have different characteristics, especially the permeability of water vapor that will affect the quality of packaged products. Important quality parameters in dry food products such as pegagan chips are crisp where it will be damaged by water vapor which causes loss of crispness due to increased moisture content so that the determination of shelf life can be measured with a critical moisture content approach. The Shelf life of a product must be included in the packaging label in accordance with Government Regulation No. 69 of 1999. The shelf life information is very important for the consumer to ensure the product is feasible and safe for consumption. Therefore, the research is related to the influence of the type of packaging on the shelf life of pegagan chips with a critical moisture content approach. The purpose of this research were to determine the permeability of polyethylene (PE) packaging and standing pouch aluminum foil; and to estimate shelf life of pegagan chips.

2. MATERIAL AND METHODS

2.1 Initial Moisture Content

Determine the initial moisture content by gravimetric method by weighing as much as 2 grams of sample and dried at oven 105 °C for 24 hours and put in desiccator for 15 minutes then weighed (Wijaya, I Ketut, dan Ni Made, 2014) Calculation of moisture value using the following formula:

$$\text{Moisture content}\left(\frac{\text{g } H_2O}{\text{g solid}}\right)=\frac{\text{the wight of initial sample - the weight of dried sample}}{\text{the weight of dried sample}}\ldots\ldots\ldots\ldots(1)$$

2.2 Determination of critical moisture content

Determination of critical moisture content using organoleptic test of hedonic quality (crispiness) with 30 panelists to give a score of 1-7 where the score of one is not like and score of seven is very like. The samples presented to the panelists had different moisture content from different storage length which were 0 minutes, 96 minutes, 192 minutes, 288 minutes, 384 minutes, and 480 minutes at room temperature of 28 ° C without packaging. The chips were laid on top of perforated baskets st the above of an open 25 x 25 x 10 plastic container containing 3000 ml of water (Fitria, 2007 (Nagara, 2016). The average datas of panelist assessment scores with the results of measurements of each sample moisture content were plotted into graphic. The result of the linear equation of the graph of the value of X in substitution with score 3 which states the sample begins to have rejection from the panelist which then results into the critical moisture content of the sample (Hutasoit, 2009).

2.3 Determination of isotherm sorption curve

Isotherm sorption curve was determination by preparing saturated salt solution then dissolving the salt into 100 ml of aquadest until the salt crystals were insolubled. The salts that used were NaBr, KI, NaCl, KCl, and KNO_3. Then, 2 grams of pegagan chips were put in the bottle. The weighed bottle contained the sample then inserted in a desiccator that contained the saturated salt.

The daily samples were weighed 24-hourly periodically until constant. The sample weight is constant if the three-day weighing increment are not more than 2 mg for the sample stored at RH below 90% and not exceeding 10 mg for the sample stored at RH above 90%. Then, the water content of constant samples were determined by gravimetric method using 105 °C oven for 24 hours. The above procedure refers to research (Taufik, 2014) (Hutasoit, 2009).

2.4 Determination of packaging permeability value (k/x)

Determining the value of the packaging permeability by determining the WVTR value first. WVTR values were obtained by testing using a WVTR cup. The WVTR cup is filled with a silica gel weighing 10 grams later and pasted with a package that has been rounded to the shape of the cup. The WVTR cup is further inserted in a jar of saturated salt NaCl and stored in an incubator temperature of 28 °C for 2x24 hours. The WVTR cup is weighed periodically every 2 hours. The k/x value is obtained by dividing the packaging WVTR value by the multiplication of the vapor pressure value at a temperature of 28 °C with a RH value of 75.5% (Anggraeni, 2016).

2.5 Determination of supporting parameters

The supporting parameters in determining the shelf life of the sample include the surface area of the packaging (A) used by multiplying the length and width values of the two sides of the package, the vapor saturated water vapor pressure (Po), temperature of 28°C obtained from (Labuza, 1984), solid product (Ws) obtained from the weight of one packing product minus the initial moisture content of the product (Faridah et al, 2013).

2.6 Determination of shelf life

The data obtained from the test are the initial moisture value (Mo), the critical moisture content (Mi), the equilibrium moisture content (Me), the vapor permeability constant (k/x), the packaging surface area (A), the solid weight of the product (Ws), pure water saturated vapor pressure (Po) temperature 28°C, slope of the curve slope (b) of selected isotherm sorption model curve, then all the data is entered in the Labuza equation to determine its shelf life. The equation for the calculation of shelf life as follows:

$$t = \frac{\ln\frac{(Me-Mo)}{(Me-Mc)}}{\frac{k}{x}\left(\frac{A}{Ws}\right)\frac{Po}{b}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Information:
t = estimated helf life (days)
Me = moisture content of the product (g H 2O / g solid)
Mo = initial moisture content of the produc t (g H2O / g solid)
Mc = critical moisture content (g H2O / g solid)
k/x = water vapor permeability of packagi ng (g / m2 / day / mmHg)
A = surface area of packaging (m2)
Ws = weight of solids per pack (g)
Po = water vapor pressure (mmHg)
b = slope of isotherm sorption curve

3. RESULTS AND DISCUSIONS

3.1 Initial Moisture Content

The initial moisture content of pegagan chips were 1.97% (wb) or 2.01% (db).

3.2 Critical Moisture Content

The critical moisture content (Mc) is the lowest moisture content in which the panelists start to dislike the product because of unwanted change on the product (Faridah et al, 2013). The critical moisture content in this study was determined by organoleptic test. The quality parameters tested were the crispiness of pegagan chips. Crispy parameter was chosen because texture is the most important characteristics for dry food product. Dry products tends to absorp water vapor resulting a decrease in product quality because the products become soft or not crunchy.

Furthermore, the organoleptic test of hedonic quality was performed to determine the critical moisture content of pegagan chips. Sample preparation was done by storing chips without packaging with some time interval so it has different moisture content. The graph of the moisture content relationship with the storage time can be seen in Figure 1.

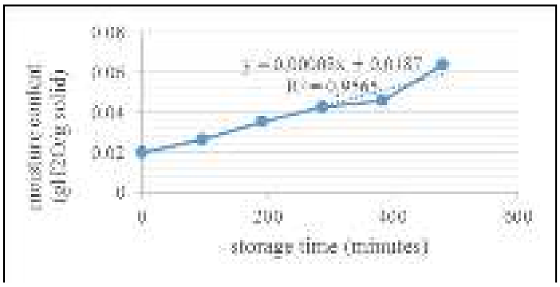

Figure 1. The relationship of moisture content with storage time

Based on Figure 1 it can be seen that the longer the storage, the higher water content. This is consistent according to (Roomania, 2015), which stated that the longer the storage, the moisture content of dry food products has increased. This is due to the migration of some water vapor from the environment into the product. This process is called adsorption where the material will absorb water if the relative humidity of the air is higher than the relative humidity of the foodstuff (Mustafidah dan Simon, 2015).

Samples of stored chips along with a later hedonic quality test questionnaire were presented to thirty panelists to be tested on the panelists' discretion on different chips samples. In addition the chips samples were also tested for moisture content with an oven for 24 hours. The panelists were asked to score a score of 1 (very dislike) to 7 (very like) on each chips sample. The average scores for each samples were plotted against moisture content on a graph (Figure 2).

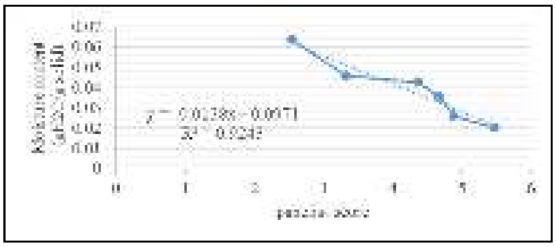

Figure 2. Relationship of moisture content with hedonic score of pegagan chips

Based on Figure 2, it can be seen that the higher moisture content, the lower hedonic scores. Thus, linear regression equation was y = -0.0138x + 0.0971 with value R2 equal to 0.9243. The critical moisture content was set at the third favorite score when the panelist stated rather dislike. Critical moisture content is determined on the assessment rather dislike not in the assessment of dislike because in this condition the product is considered to have been rejected by consumers and this condition must be wary of to ensure customer satisfaction and comfort as well as minimize the risk of damage to the product (Fitria, 2007). Thus, value of critical moisture content of the samples was calculated by substituting X value on the linear equation with score 3. From this calculation, the obtained critical moisture content was 0.0557 gH2O/g solid. The value of R2 in the linear equation shows the accuracy in describing the actual condition. The higher the R2 value in the equation the higher the closeness of the relationship between the two factors being compared (Mustafidah dan Simon, 2015).

3.3 Moisture Content Equilibrium (Me)

When a food product is left open, its moisture content will balance with the surrounding humidity, the moisture content is called a balanced moisture content (Itaoke, 2012). The moisture content of equilibrium in this study was determined by storing samples at various RHs using a saturated salt solution at room temperature. The saturated salt solution used and the RH value can be seen in Table 1. During storage, the samples weight increased or decreased. This is because water vapor moves from product to environment (adsorption) or from the environment to the product (desorption) until it reaches a constant weight. The displacement of water vapor is due to the difference of RH between the product and its environment. Water vapor will move from high RH to lower RH. The constant weight is marked by the difference of three consecutive weighing days not exceeding 2 mg for samples stored at RH below 90% and not exceeding 10 mg for samples stored in RH above 90%. The constant samples were then measured in gravimetric moisture content by 24 hours. The result of measurement of equilibrium moisture content at various RH can be seen in Table 2.

Table 1. Equilibrium moisture content (Me) at various RH

Garam	RH (%)	Me (gH_2O/g padatan)
NaBr	57,5	0,0816
KI	69,0	0,1141
NaCl	75,5	0,1199
KCl	84,0	0,1555
KNO_3	93,0	0,2221

Based on Table 1, it can be seen that the higher the RH, the higher the value of equilibrium moisture content. The moisture content of equilibrium in this study showed the addition of weight from the initial moisture content indicated the process of food hydration was the adsorption. This is in accordance with the literature where the equilibrium moisture content is important to determine the increase or decrease in the moisture content of the material under certain temperature conditions. If the relative humidity of the air is higher than the relative humidity of the food then the material will absorb water or the adsorption process occurs (Fitria, 2007). The higher the RH value of the storage environment the more water vapor will be absorbed by the food. Naturally, agricultural products both before and after processing are hygroscopic or have hydratating properties. These hydratating properties are represented by an isothermal curve showing the relationship between the moisture content of the material with the relative humidity of the space or water balance (Kumalaningsih, 2016).

3.4 Isothermal Sorption Curve

Isothermal sorption curve is a curve that can describe the relationship between aw with moisture content per gram of food (Jamaluddin, Robert, dan Deddie, 2014). Isothermal sorption curves describe the properties of food hydratation, i.e. the ability of food can naturally absorb water from the surrounding air and can otherwise release some of the water contained therein into the air (Wijaya, I Ketut, dan Ni Made, 2014). So this curve is widely used in the determination of shelf life of foodstuffs. The curve is obtained from the equilibrium moisture value of a given RH which is converted into aw values and plotted into a graph. The graph between equilibrium moisture value and aw value in this study can be seen in Figure 3.

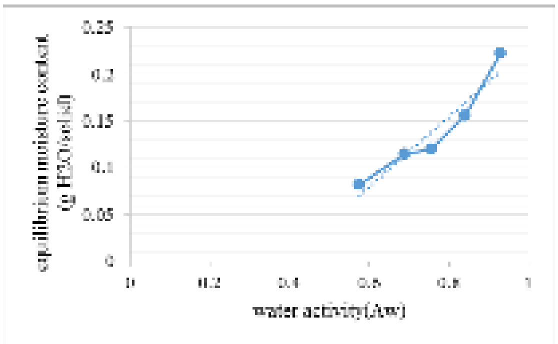

Figure 3. Relationship of equilibrium moisture content with aw value

Based on Figure 3 the isotherm of sorption curves that are formed can look sigmoid (resembling the letter S) but not perfect. The results were supported by (Labuza, 1984) where food with low moisture content generally has a tendency of isotermic sorption curve in the form of sigmoid. However, the slope of the sigmoid isotherm sorption curve may vary as it was influenced by the nature of the food, the temperature, the speed of adsorption and the desorption occurring during the storage process (Jamaluddin, Robert, dan Deddie, 2014). The isotherm sorption curve is typical for any food product but is generally sigmoid-shaped (resembling the letter S), because it is generally composed of a mixture of several components (Jamaluddin, Robert, dan Deddie, 2014).

3.5 Model Decision Test

The sorption isotherm equation models were made to obtain a more reliable trend of water activity and moisture content (Kumalaningsih, 2016). Various models of equations are used to obtain high curvature curves and calculated Mean Relative Determination (MRD) values to determine the model precision of the isotherm sorption curve. High saturation can also be seen from the increasingly close isotherm sorption curve of the research results with isotherm sorption curve of calculation results from various equation models (Winarno, 2004). Various models of equations used in this study include Henderson, Hasley, Caurie, Oswin, Chen Clayton, and GAB. The equation is chosen because it can represent isotherm sorption curves over a wide range of water activity values (Faridah et al, 2013).

The equations of the various models used and the results of the MRD calculations in this study can be seen in Table 2.

Table 2. The equations of various isotherm sorption curve models and calculations value of MRD

Model	Linear Equation	MRD (%)
Henderson	log [ln(1/(1-aw))]=1,1820+1,1491 Log Me	2,8729
Hasley	log [ln(1/aw)]=-2,4537-2,0685 Log Me	4,2466
Caurie	ln Me= -4,0804 -2,7009 aw	5,2408
Oswin	ln Me= -2,5819 + 0,4239 ln [aw/(1-aw)]	3,5435
Chen Clayton	ln [ln(1/aw)]= 0,5704 - 14,539 Me	3,4288
GAB	Me=0,2653aw/(1−0,8365 aw)(1-5,2621 aw)	3,3724

Based on Table 2 the above linear equations were used to calculate the equilibrium moisture value. Some models of the equations to facilitate the calculation are then transformed into linear equations (y = a + bx) with logarithmic (log) and / or normal logarithmic logs (ln). Based on the isotherm sorption curve that is formed can be known that the most squeeze between the curve of the research results and the results of the calculation is the Henderson model. Next is calculation of model accuracy (MRD) to determine the most appropriate model. The chosen model is the one with the smallest MRD value in which the model can accurately depict the isotherm sorption curve.

Based on Table 1.2 it can be seen that the equation model that has the smallest MRD value was the Henderson model with a value of 2.87 and can accurately depict the isotherm sorption curve. The Henderson model, Oswin, Chen Clayton, and GAB can describe the isotherm sorption curve appropriately because it had an MRD value of <5. The Hasley and Caurie models can illustrate the isotherm sorption curve quite precisely because the MRD value was between <MRD <10. So the equation model selected to illustrate the isotermic sorption curve of the penny chains which yields the curves with the high degree of Henderson's model with the log equation [ln (1 / (1-aw))] = 1.1820 + 1.1491 Log Me. The equation was used to determine the equilibrium moisture content that goes into the shelf life equation. Equilibrium moisture content was at 0.1244 gH2O / solid by substitution of RH storage value converted to aw value of 0.75. The isotherm sorption curve for the chosen model of Henderson can be seen in Figure 4.

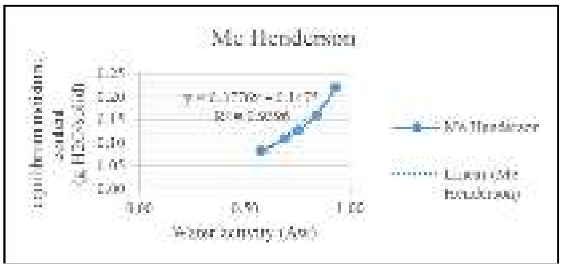

Figure 4. Selected isotherm sorption curves (Model Henderson)

Based on Figure 4, it can be seen the slope value (b) isotherm sorption curve for the calculation of shelf life of 0.3776. The Henderson model is one of the most widely used isothermic equations in dry food, especially grains. The Henderson model is empirically able to describe the condition of food at room temperature. The Henderson model has been widely used to analyze the character of products containing starch and protein (Budijanto, Azis, dan Yuni, 2010). This is consistent with the characteristics of Centella asiatic chips which are included in dried and starchy foods which are indicated by high carbohydrate levels.

3.6 Supporting Variables Determination of Shelf life

The supporting variables in determining shelf life are vapor packaging permeability (k / x), packaging surface area (A), pure water vapor pressure at 28 ° C (Po), and solid weight per pack (Ws). Moisture vapor permeability is the velocity or rate of water vapor transmission through a unit of surface area of a flat surface material of a certain thickness as a result of the difference of the water vapor unit between the product surface at a certain temperature and RH con- cession (Fitria, 2007). The permeability of the packing material should be known to determine the shelf life of a packaged material and the deterioration criterion of the packaged material, since with the permeability of the packing material it can be calculated the amount of water vapor entering for a certain period of time (Ikasari et al, 2017). The smaller the permeability of packaging means that the less water vapor can penetrate the packaging so the better the packaging protects the product inside. Packaging permeability can be determined by determining the value of Water Vapor Transmission Rate (WVTR) first. WVTR in this study was conducted by WVTR bowl method containing silica gel then stored in saturated salt NaCl solution at 28°C for 2x24 hours. The WVTR cup is weighed periodically every 2 hours. The WVTR plate weight and weighing clock data are plotted into a graph so that the linear regression value can be known. The linear regression equation is a slope value for use in WVTR calculations. The value of the slope is divided by the surface area of the tested packing. Furthermore, in order to obtain the packaging permeability value (k/x), the WVTR value of the packaging is divided by the multiplication of the moisture pressure with the RH value of storage produced by the saturated salt solution. The result of calculation of packaging permeability on the PE packing, standing pouch PP and standing pouch aluminum foil in this study can be seen in Table 3.

Table 3. Calculation of packaging permeability (Temperature 28°C and RH 75.5%)

Packaging	Thick-ness (mm)	WVTR value (g/m^2.day)	Permeability (k/x) (g/day.m^2.mm Hg)
PE	0,0567	3,5631	0,1665
Standing pouch Aluminium foil	0,1033	1,2833	0,0603

WVTR value of PE packing was 3,5621 g/m2/day and standing pouch aluminum foil equal to 1,2833 g/m2/day. The tested packed area was obtained by 0,0016 m2 from the packaging area placed on a circular WVTR plate with a diameter of 0.045m2 so it was calculated by the area of the circle area. Furthermore, to determine the permeability value, the WVTR value of each pack was divided by the result of the multiplication between the water vapor pressure of 28 ° C at 28.349 and the RH value of 75.5% (0.755) under test conditions. The value of PE plastic packing permeability (k/x) of 0.1665g/hari.m2.mmHg and standing pouch 0.0603 g/hari.m2.mmHg

Another variable in determining the shelf life was the surface area of the packaging used. The surface area of the PE packaging was calculated by multiplying the length and width of the packaging on both sides. As for the packaging pouch aluminum foil obtained by multiplying the length and width then reduced by the area of the lower left triangle on the right and left on both sides of the package. The rectangular PE plastic packaging has a length of 0.30 m and a width of 0.18 m so that the surface area of the packaging obtained value of 0.0977 m2. Plastic packaging of aluminum foil standing pouch obtained result 0,0389 m2. The next variable was the value of water vapor pressure determined at 28°C could beseen in the literature table water vapor pressure Labuza (Labuza, 1984) that is equal to 28.349 mmHg.

The next variable was the weight of solids per pack (Ws) obtained by determining the initial weight of the product and then corrected with the initial moisture content. The initial weight of the product for the PE packaging was 250 gram specified by the manufacturer while the standing pouch packaging was 60 grams. The weight of packaging solids calculated for PE packaging was 245,0740 gram and for the standing pouch packaging 58,8178 gram.

3.7 Determination of Shelf life

Various initial moisture content, critical moisture content, equilibrium moisture content, Henderson's model curve slope, packaging permeability, packaging area, water vapor pressure and packed solid weight per packet were then included in the Labuza shelf life determination formula. Determination of shelf life in this study was determined at 75% RH storage where RH was selected because it is generally used in storage of food products (Hutasoit, 2009). The calculation results for the determination of chimpanzee aging chimpanzee life can be seen in Table 4.

Table 4. Calculation of shelf life of kola kola chips product at RH 75%

Parameters	Unit	Packaging PE	*Aluminium foil*
Initial moisture content	g H2O/g solid	0,0201	0,0201
Critical moisture content	g H2O/g solid	0,0557	0,0557
Equlibrum moisture content	g H2O/g solid	0,1244	0,1244
Water vapor permeability of packaging	g/m^2.day. mmHg	0,1665	0,0603
Surface area of packaging	m^2	0,0977	0,0389
Weight of solids per pack	g solid	245,0740	58,8196
Water vapor pressure 28°C	mmHg	28,3490	28,3490
Slope Henderson curve		0,3776	0,3776
Shelf life	days	83	139

Based on Table 4 it can be seen that pegagan chips packaged with different types of packaging have different shelf life as well. Estimated shelflife of pegagan chips that stored at 28 ° C and RH 75% with PE plastic packaging was 83 days and standing pouch aluminum foil was 139 days. Shelf life of pegagan chips product with standing pouch aluminum foil has longer shelf life due to lower packaging permeability value compared with PP standing standing packaging. The lower the permeability, the higher the packaging capability prevents the increase of moisture content (Fitriani et al, 2015). Dry food products such as pegagan chips should be protected from water vapor by packing using packaging with low permeability so as not to quickly lose crispness. This is in accordance with the statement of (Winarno, 2004) the lower the permeability value of bottled water, the lower the vapor diffusion rate so as to maintain texture and to extend the shelf life of the product. The shelf life of pegagan chips with PE plastic packaging is not appropriate when compared to aluminum foil standing pouch because it had a wide value of packaging and weight of solids per different packaging. Shelf life with different packaging types can be compared if the packaging used has the same surface area and packing weight. The more surface area of the packaging used, the water vapor that enters the environment will be higher and will spread widely in the packaging. This causes critical moisture content will soon be achieved and the shelf life of the product is not long (Anggraeni, 2016).

4. CONCLUSIONS

Permeability of polyethylene plastic packaging (PE) and aluminum foil standing pouch were 0.1665 g/m2.day.mmHg and 0.0603 g/m2.day.mmH, respectively. Estimated shelflife of pegagan chips using polyethylene (PE) packaging was 83 days and using aluminum foil standing pouch was 139 days. The type of packaging has an effect on the shelf life in which the packaging with a lower vapor permeability value will extend the shelf life of pegagan chips compared with the higher one.

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