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Physical Characteristics: Rehydration, Porosity Diameter, and Colors of Instant Pempek Out of Treatment with Freeze Drying Pressure

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Abstract
The objective of this study was to study the freeze drying pressure on the rehydration, the porosity diameter, and the color of the instant pempek. Pempek is a typical food of the city of Palembang, South Sumatra, Indonesia which contains lots of protein, carbohydrates, fats, and other micro nutrients. Pempek is a processed food product made from the mixture of main ingredients of milled Snakehead fish, tapioca starch, salt, and water. The dough is shaped into the forms called *lenjer* (sausage-like bar*)*, *pastel* (oyster shape), *otak-otak* (wrapped in banana leaf), *keriting* (curly), and *kapal selam* (submarine) in the form of wet pempek.Instant pempek is obtained from processing the wet pempek by using freeze drying pressure technique with the pressure of 0.002 bar, 0.004 bar, 0.006 bar and 0.008 bar at a condensing temperature of -50^{o}C. The pressure has a very significant effect on rehydration, diameter of porosity, and color (lightness, chroma, hue). Instant pempek has the characteristics of porosity diameter size 1138.21 µm, rehydration (amount of water absorbed) 17.04 g, lightness 83.01%, chroma 18.29%, and hue 89.93%.
Keywords: *Freeze Drying, Rehydration, Instant Pempek*

1. Introduction

Rehydration is the process of reverting the product from dry or instant shape into its original shape or wet shape. Jokic, et.al (2009) said that the things to consider regarding the characteristics of instant food products in relation to its condition prior to its consumption are rehydration properties, rehydration levels and rehydration capacity. The food products with high rehydration capacity can maintain the freshness of the food product. One of the ways used to get instant food product is by using freeze drying method which is the best method in drying food.

Drying is closely related with rehydration. There are some factors that are related with rehydration, namely consistency of rehydration characteristics such as water mass ratio, rehydration temperature, agitation level and determination of water content. The experiment that used rectangular pineapple measured the diffusion coefficient, the loss of solute during rehydration using high pressure (Rastogi, et.al., 2000).

Pempek which is a typical food of Palembang, South Sumatra, Indonesia, consists of several types of forms or shapes. There are large long *lenjeran* (large sausage-like bar*)*, short small *lenjeran* (small sausage-like bar*)*, *kapal selam* (submarine-like shape), *adaan* (round), *otak-otak* (wrapped in banana leaf), *pempek keriting* (curly) and *pastel* (oyster-shaped). Pempek in general is in the form of wet or semi-wet with water content of about 50-60%. This causes pempek to be susceptible to damage and has a relatively short shelf life. Karneta, et.al (2013) said that pempek lenjer in wet form that is stored at 25^{o}C can only last for 27-33 hours. Murtado, et.al (2014) said that the shelf life of pempek with the coating material of palm oil is 12 days, while with the tapioca coating and margarine coating less than 12 days. To maintain its consistency and to lengthen its shelf life so that it can last for a few months, pempek should be dried by using freeze drying to make it instant pempek.

The dried food aims to decrease the water (a_w) activity, the value of a_w that is less than 0.5 enables the food to be stored at room temperature. Instant pempek should be made capable of absorbing water easily, or it can revert to its previous condition after the product is soaked and boiled (Bonazi, et.al., 2011).

Instant foods are expected not only to have a long shelf life, but also easy to consume. A vacuum drying that is initiated with freezing will produce instant pempek with increased porosity and extended shelf life. Instant foods that have pores are expected to be easily rehydrated.

Carrots that are dried by means of freeze drying have a larger porosity (0.8-1.0) compared with those being dried by using water drying (0.12-0.14) (Jokic, et.al., 2009). The study using temperature of -35^{o}C at a pressure of 0.004 bar produced 90% porosity in apple, and 80-85% in carrot, potato and banana (Madiouli, et.al., 2012). The fresh quinces of 11x11x11 mm are dried by using freeze drying starting with the freezing at -25^{o}C, then it is followed with the freezing in the freeze drying with 0.0014 bar at condensing temperature of -50^{o}C. This study resulted in a porosity of 0.7-0.8 higher than the results of the fluid bed drying, tray drying, and infrared drying (Koc, et.al., 2008)). Food dried through the freeze drying process is expected to have a high quality and a very small possibility of or no possibility of experiencing shrinkage at all (Ratti (2013).

The freezing can be done quickly at -40°C, or slowly at -24°C. The frozen product is stored in the vacuum

chamber for sublimation by keeping the vacuum chamber at a pressure of 610.5 Pa or 0.006105 bar (Hariyadi, 2013).

2. Experiment

2.1 Experimental Procedure

Instant pempek is produced from wet pempek whose ingredients consist of: milled cork fish, tapioca flour, fine salt, and water. The materials are obtained from local market in Palembang City, South Sumatra, Indonesia. The amount of tapioca flour is 450 g, milled cork fish meat is 550 g, and salt is 2.5% (11.25 g) of tapioca starch weight. The volume of ice water is as much as 50% (225 ml) of tapioca flour weight. The milled cork fish, salt and water are mixed evenly as dough 1. The dough 1 is added with tapioca starch little by little while stirring it slowly until evenly distributed and the ingredients can be formed as dough 2. The dough 2 weighs 260 g. Pempek of long *lenjeran* with a diameter of 4 cm and a length 20 cm is made. The cooking is done by boiling it for 20 minutes until it is cooked or marked by the floating of pempek lenjeran. Then the pempek is lifted and drained, cut as a sample with a diameter of 4 cm and a length or a height of 3 cm.

Preparation of drying. Pempek is put into a chamber, then the chamber is put into a freezer with a temperature of -20^{o}C for 48 hours. The freeze dryer is turned on until it reaches a temperature of -50^{o}C for 2 hours. Connect the chamber to the rubber of freeze dryer. A vacum is switched on and the tap of the freeze dryer is opened. The trial arrangement of pressure (P) and time (T) is performed according to the treatment. The drying is done in the freeze dryer at 0.002 bar, 0.004 bar, 0.006 bar and 0.008 bar (according to the treatment), and the drying of pempek lenjer with freeze drying is done for 38 hours, 40 hours, 42 hours, and 44 hours (in accordance with the treatment), and instant pempek is produced.

2.2 Rehydration

Rehydration measurement is conducted to disclose the amount of water absorbed by instant pempek through the process of putting the instant pempek in the water and soaking it, then weighing it. The difference between the weight of pempek lenjer that has been soaked in the water and that of the instant pempek lenjer before being soaked is the amount of water absorbed by the instant pempek.

$R = R_2 - R_1$

In which :

R = rehydration (g)

R1 = the weight of Instant pempek (g)

R2 = the weight of Instant pempek after being soaked (g)

2.3 Porosity diameter

The diameter porosity of the instant pempek is measured by using *Scanning Electron Miscroscopy* (*SEM*). The stages are as follows: Cut the instant pempek into cubes with the size of 1x1 cm; Prepare the specimen holder that has been coated with carbon tape; Attach the sample on the surface of the carbon tape; Then coating is done with sputter coating tool quorum type Q150R ES. The coating is done by using the material of gold coating, sputter current is 20 mA, sputter time is 60 seconds. The samples that have been coated in specimen holder are then mounted on the stage for SEM analysis. The stage that already contains samples is then put in the chamber and photographed using SEM of ZEISS brand with the type tool of EVO MA10, and the image is taken by using SE detector, WD 10.0 mm, and EHT 14.00 kV)

2.4 Colors

The color of instant pempek is measured by using Color Reader CR-300, with the procedures as follows: The color reader is turned on and the function buttons are activated to select and determine the value and the number used; Press calibarate button (yellow); Set the condition of a* and b* at zero and L (lightness) = 100; The sample is inserted into transparent container (clear plastic / blank); Place the color shooter (calor reader) above the meter reader; Press measure once and wait until it is photographed 3 times; Attach the sample to the tool of Photographer and the numbers will appear L (%), H (%), and C (%) on the tool and record them.

3. Results and Discussion

3.1 Analysis of rehydration diversity, porosity diameter, and color

Table 1. The results of the diversity analysis of pressure treatment response and the time of freeze drying on the rehydration, porosity diameter, lightness, chroma, and hue of the istant pempek.

No	Variables	Pressure Treatment (P)	KK (%)	R^2
1	Rehydration	**	1.608	0.995
2	Diameter porosity	**	0.053	0.999
3	Lightness	**	0.357	0.995
4	Chroma	**	0.132	0.999
5	Hue	**	0.036	0.999

Notes :
**) = Very significantly influential

The results of the diversity analysis, as shown in Table 1, reveal that the pressure treatment had a very significant effect on the rehydration, porosity area, lightness, chroma, and hue of the instant pempek.

3.2 Average and real difference test of Duncan distance rehydration, diameter porosity, and color

The data in Table 2 show the treatment of P3 (a pressure of 0.006 bar) for rehydration parameter significantly different from the treatment of P2, P1 and P4 with an average of 17.04 g. For the parameter of porosity diameter, the treatment of P3 was carried out which was significantly different from that of P1, P2 and P4 with average of 1138.21 µm; For the lightness parameter, the treatment of P1 was was performed which was significantly different from the treatment of P2, P3 and P4 with an avarage of 83.01; For the chroma parameter, the treatment P4 was carried out which was significantly different from other treatments with an average of 18.29; For the hue parameter, the treatment of P4 was carried out with an average of 89.93. The rehydration occurs better than with other treatments. The food is more porous, it will absorb water more quickly and will increase the water content or water content in the food will increase until it approaches or reaches equilibrium (Khalloufi, et.al., 2009).

Table 2. Mean and Duncan's Real Distance Difference Test on the Influence of Pressure on rehydration, porosity diameter, and color

Variables	Treatment			
	P1	P2	P3	P4
Rehydration	11.36± 1.378d	15.70± 0.839b	17.04± 0.964a	14.15± 0.788c
Diameter Porosity	530.59 ± 40.63d	903.22 ± 53.99c	1138.21 ± 9.64a	1021.57 ± 6.41b
Lightness	83.01± 0.824a	82.21± 4.549b	80.14± 3.196c	79.94± 2.066d
Chroma	16.25± 0.881d	17.27± 0.899c	17.97± 0.649b	18.29± 0.150a
Hue	88.64± 0.941d	89.32± 0.613c	89.70± 1.088b	89.93± 0.747a

Notes: The numbers followed by different letters mean really different

3.3 The relationship between pressure and rehydration, porosity diameter, and color

The data in Figure 1 show the relationship between pressure and rehydration of R^2 = 0.93. Rehydration will increase as the pressure rises to the pressure of 0.006 bar and then will decrease until it comes to the pressure of 0.008 bar. The foods undergoing freeze drying process will accelerate the rehydration of the product (Lombrada, 2009).

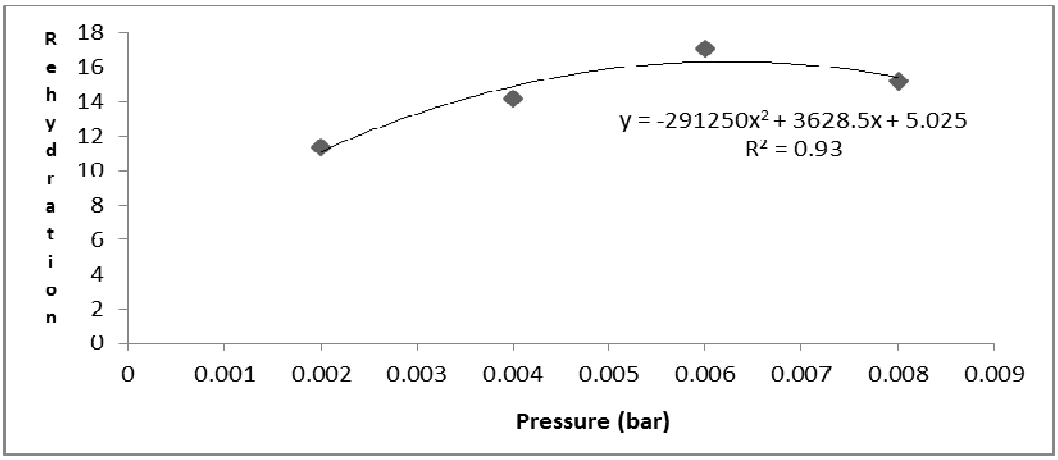

Figure 1. The relationship between pressure and rehydration

The data in Figure 2 show the relationship between pressure and the porosity diameter of R^2 = 0.989. The

porosity diameter will increase with the increase of the pressure until the pressure reaches 0.006 bar and then it will decrease up to the pressure of 0.008 bar. Jokic, et.al (2009) said that food can undergo changes during drying, namely the structural / physical properties, such as porosity. Hao, et.al (2016) said that porous food means that it has a lot of pores that will facilitate and speed up rehydration. And porosity is one of the factors that influences the transfer of heat that depends very much on the material mass and the thickness of the material.

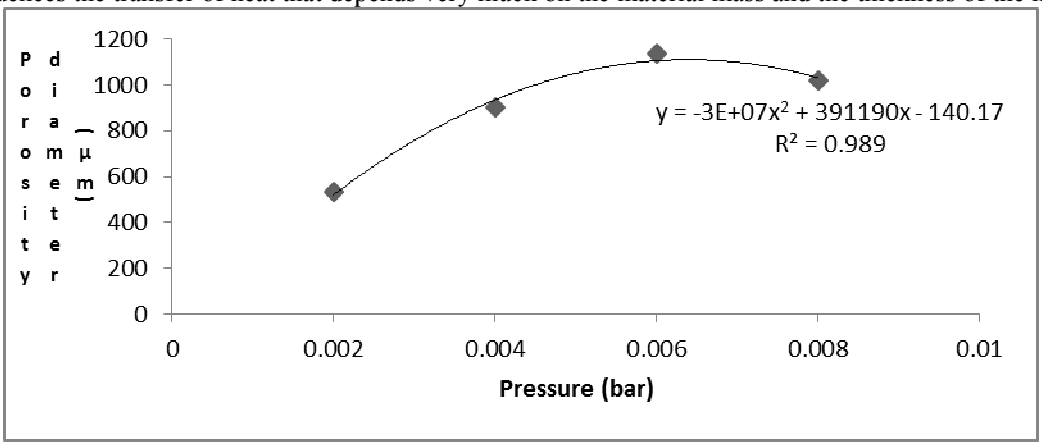

Figure 2. The relationship between pressure and porosity diameter

The data in Figure 3 show that there is a relationship between pressure and lightness of $R^2 = 0.929$. Lightness will decrease with increasing pressure up to the pressure of 0.008 bar. The color of dry food products is strongly influenced by the drying temperature. From the results of the study Jokic, et.al (2009) of the dry asparagus, the material for dry sample is obtained. The higher the temperature or the smaller the temperature or below zero temperature, the higher the level of lightness (L*). For Freeze drying is directed more to green color, while the others are directed to yellow color. The best color resulting from the freeze drying method is obtained at minimum temperature of -10°C.

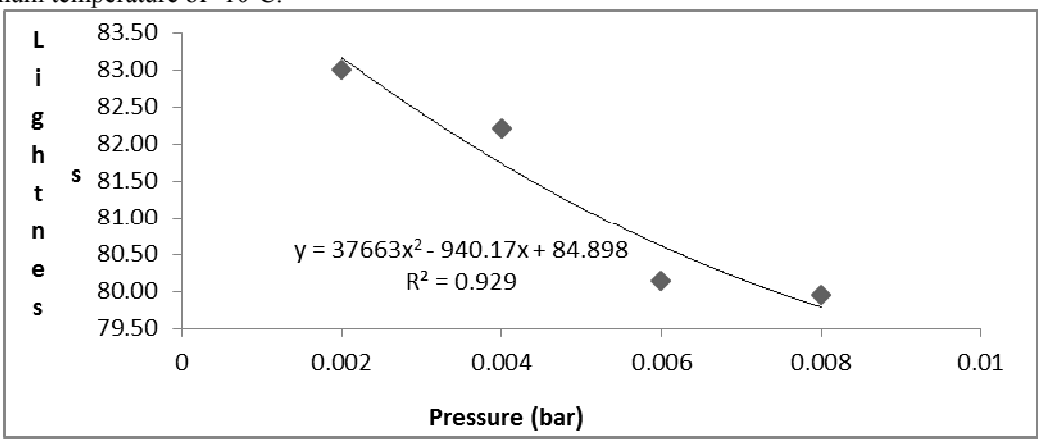

Figure 3. The relationship between pressure and lightness diameter

The data in Figure 4 show that there is a relationship between pressure and chroma of $R^2 = 0.9999$. The chroma will increase with the increase of pressure until the pressure of 0.008 bar, and after that there is a tendency that chroma will decrease.

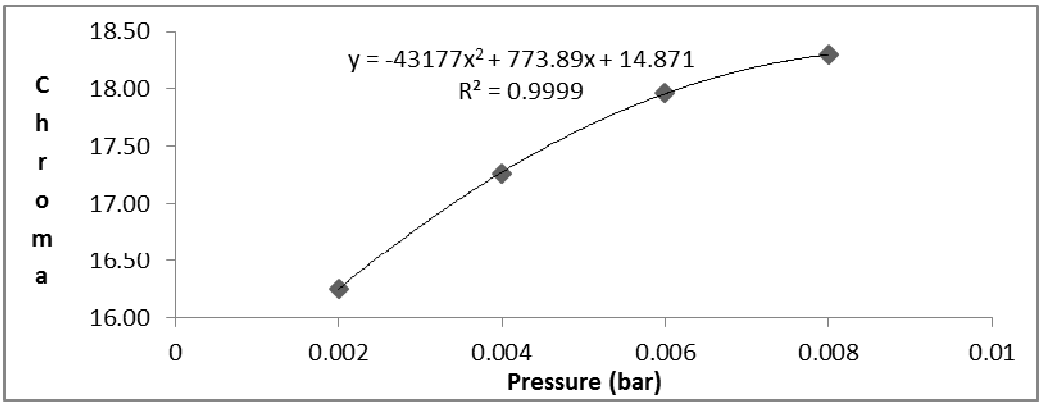

Figure 4. The relationship between pressure and chroma diameter

The data in Figure 5 show the relationship between pressure hue of $R^2 = 0.9986$. Hue will increase with the increase of pressure up to the pressure of 0.008 bar and then it will decline steadily after reaching the pressure of 0.008 bar.

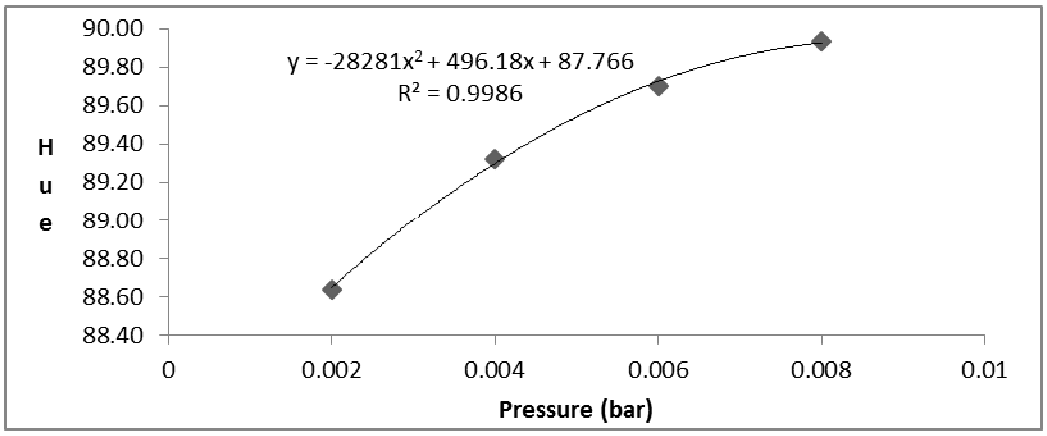

Figure 5. The relationship between pressure and hue diameter

3.4 The relationship between rehydration and the effect of pressure on porosity diameter and color

The data in Figure 6 show the relationship between the diameter of porosity and rehydration of $R^2 = 0.9985$. Rehydration will increase with the increase of porosity diameter. Jokic, et.al (2009) said that food can undergo changes during drying process, namely the structural or physical properties such as porosity, thus allowing rehydration to increase. Rastogi, et.al (2000) said that the rehydrated food is related to the amount or ratio of the water mass and the degree of agitation in the dried or the instant food.

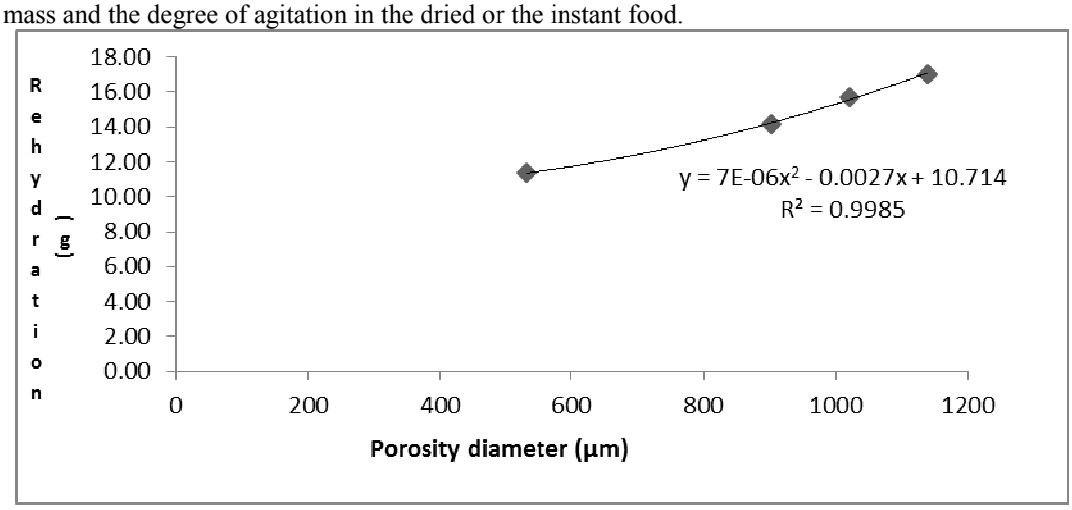

Figure 6. Rehydration effect of pressure on porosity diameter

The data in Figure 7 show that the relationship between lightness and rehydration is $R^2 = 0.9636$. Rehydration will increase with the increase of lightness up to 82-83% . Then gradually the rehydration will decrease with the increase of lightness.

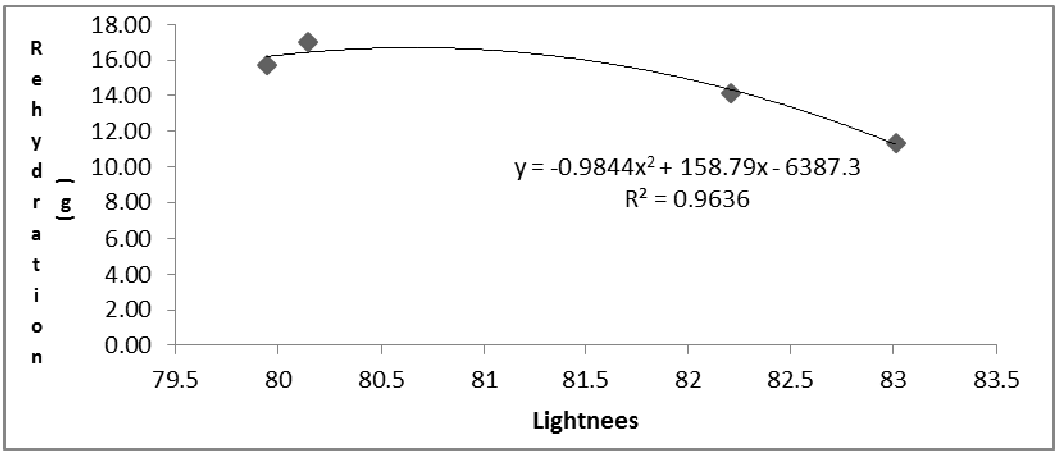

Figure 7. Rehydration of pressure effect on lightness

The data in Figure 8 show the relationship between chroma and rehydration of $R^2 = 0.9023$. Rehydration will increase as chroma increases up to 17.50-18.00% and then rehydration will decrease with the increase of chroma.

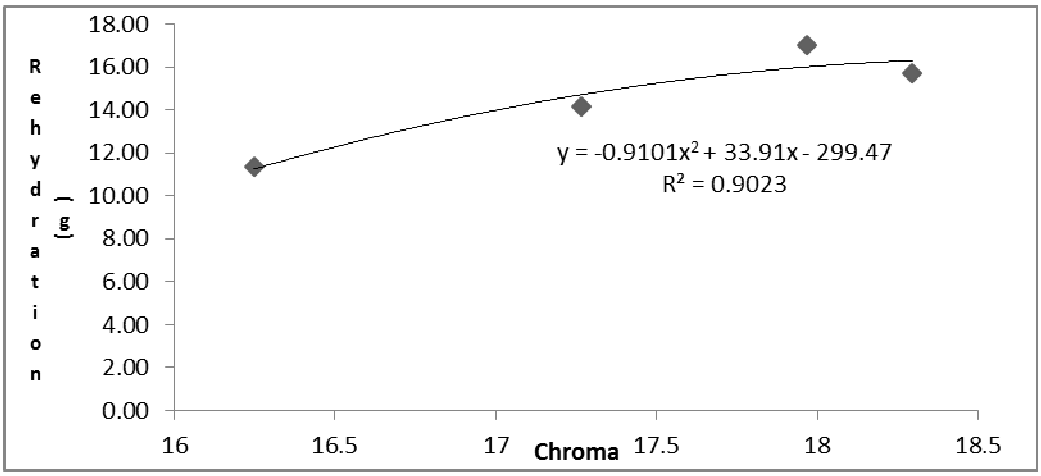

Figure 8. Rehydration of pressure effect on chroma

The data in Figure 9 show that the relationship of hue and rehydration is $R^2 = 0.8848$. Rehydration will increase with the increase of hue until hue reaches 89.50% and then the rehydration will decrease with the increase of hue.

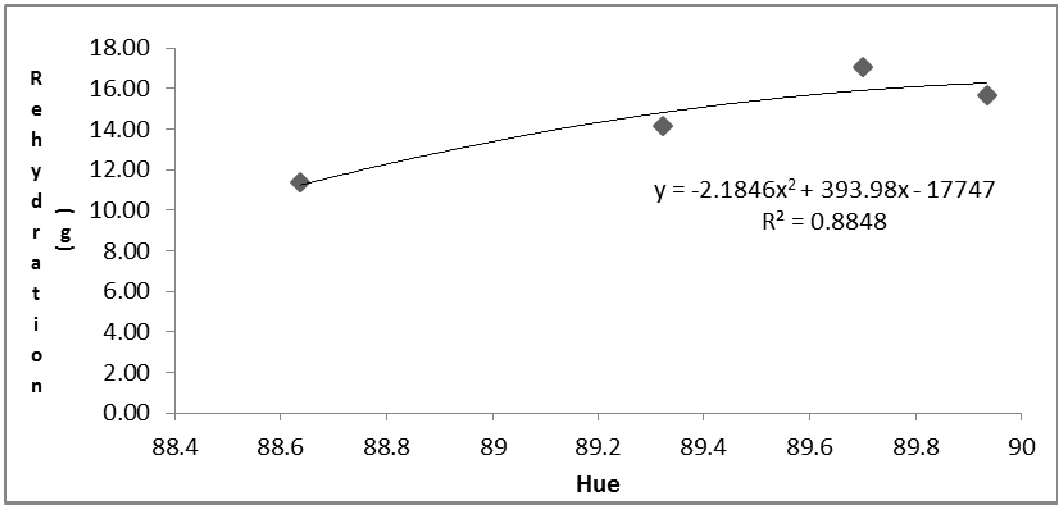

Figure 9. Rehydration of pressure effect on hue

4. Conclusions

Instant pempek is a dry food product produced through the process of freeze drying method with pressure regulation. Pempek which is converted into instant pempek is tube-shaped large wet pempek lenjer with the

height of 3 cm and the diameter of 4 cm. The results of the pressure treatment of 0.002 bar (P1), 0.004 bar (P2), 0.006 bar (P3), and 0.008 bar (P4) reveal that the pressure has a significant effect on rehydration, porosity diameter, lightness, chroma, and hue. The instant pempek at the pressure of 0.006 bar (P3) has physical characteristics as follows: rehydration (amount of water absorbed) is 17.04 g, porosity diameter is 1138.21 μm which is more bigger than the pressure treatment of 0.002 bar (P1), 0.004 bar (P2), and 0.008 bar (P4); And it has 80.14% of lightness, 17.97% of chroma, and 89.70% of hue. Rehydration can affect and improve lightness, chroma, and hue.

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