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Effect Of Liquid Smoke And Carrageenan To Beef Meatball Texture And Lightness

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Abstract

Beef meatballs lots sold in the market with additional preservatives that are not recommended for food. This study will discuss the use of liquid smoke to preserve beef meatballs with the addition of carrageenan as firmness agent. The purpose of this study was to determine the optimum composition of addition of liquid smoke and carrageenan. Beef meatballs prepared by adding liquid smoke and carrageenan on a particular variation into meatballs dough. Liquid smoke variation used was 0.5%-1%, and carrageenan variation used was 0.5%-1.5%. The meatballs that has been created and then stored for 0, 12, 24, and 36 hours. The results of optimization using RSM shows the maximum value of hardness and springness of beef meatballs obtained in 24 hours of storage. The optimum composition of liquid smoke and carrageenan on the hardness and springness obtained on the liquid smoke concentration 0.755% and 1.04% carrageenan. The addition of carrageenan in beef meatballs provide a dominant influence on the texture. Lightness test is not a significant effect on the addition of liquid smoke and carrageenan, but give significant effect on the storage time, the longer the storage time, the lightness of the color of beef meatballs was decrease

Kata kunci: *beef meatballs, liquid smoke, carragenan, texture, lightness*

INTRODUCTION

Today, processed food products in the market is very disturbing because of the addition of formaldehyde as a preservative agent. This preservative has aldehydes and will be react easily with proteins. Protein will be lost after binding with formalin, and meat will be more supple. Meat will be more durable because of the loss of bacteria that produce acid compounds in meat (Aras, 2013).

Liquid smoke obtained from condensing the steam combustion from materials which contains lignin, cellulose, hemicellulose and other carbon compounds. Liquid smoke obtained from the pyrolysis process has the ability to preserve foodstuffs for their acidic compounds, phenolic and carbonyl (Wijaya et al., 2008). Carrageenan function as emulsifiers, stabilizers, gelling, and clotting. Carrageenan has water binding properties that affect to the yield and chewy texture in meat products.

Preservation process which commonly used with liquid smoke is soaking the raw material in liquid smoke. Lingbeck et al., (2014) have studied the function of liquid smoke as an antimicrobial in food preservation. Arnim et al, (2012) have conducted experiments using liquid smoke in the preservation of meatballs with 0-7% concentration of liquid smoke. The results showed that the meatballs with the addition of 7% liquid smoke can increase the durability of up to 15 days. H. Ulu (2006) have studied the effect of the use of carrageenan in the beef meatballs manufacture.

Response surface methodology is a method to obtain the optimum point of several variables that aims to optimize the response. This research will be making meatballs with the addition of liquid smoke as a preservative agent and carrageenan as an anti-bacterial with the particular composition analyzed by RSM to get the optimum value in order to produce meatballs with texture and optimal brightness.

EXPERIMENTAL DETAILS

Making meatballs

Meat surface is cleaned from fat and tendons, then weighed 1 kg of meat and added 200 grams of ice and 50 grams of salt. Furthermore, milled in a meat grinder. The ground meat inserted into the crusher and added 100 grams of tapioca, 500 g of garlic paste, 2 teaspoons of white pepper powder and 2 eggs. divided the mixture into 12 samples and added liquid smoke and carrageenan with varian concentrations according to Table 2 (Chrismanuel, 2012). The mixture crushed for a half minute and then released for printing meatballs were printed immediately by put in warm water with a temperature of 60 0C to 80 0C and allowed to float. Meatballs transferred into boiling water and cooked about 10 minutes. The meatballs were stored for 36 hours at room temperature, sampled every 12 hours and tested include hardness texture and springness using Texture analyzer and brightness using Digital Color Meter.

Response Surface Methodology (RSM) Optimization

Response Surface Methodology (RSM) is a method of combination of mathematical and statistical techniques used to make a model and analyze the y response which influenced by several variables / x factors in order to optimize the response. To facilitate the computation process, the original concentration of liquid smoke (A) variables can be transformed, into a variable code (X1) and concentrations of carrageenan (K) into the variable code (X2), where for the concentration of liquid smoke has a level factors within DA = 0.25% and the concentration of carrageenan factor level within DK = 0.5%. Defined as follows:

$$X_1 = \frac{A - \bar{A}}{DA} \qquad X_2 = \frac{K - \acute{K}}{DK} \qquad (1)$$

The code and experiment level value in accordance with Table

Tabel 1. *Range and Level of Independent Variable*

Independent Variabel	*Range and Level*		
	Low Level (-1)	*Center Level (0)*	*High level (1)*
concentration of liquid smoke (X_1)	0,5%	0,75%	1%
concentration of carrageenan (X_2)	0,5%	1%	1,5%

RESULT AND DISSCUSION

a) Variable Optimization of Liquid Smoke Concentration and Carrageenan

Optimization of the variables used by RSM (Response Surface Method) method, using Statistica 6 software. In this study, there are variables change, the concentration of liquid smoke (x1) and the concentration of carrageenan (x2) with response is the texture of the beef meatballs includes hardness and springness. Minimum limit obtained the best results of the second experiment in terms of hardness and springness of beef meatballs. Limitation of variables obtained by determining the low level (-1) and high level (+1) on the areas best results of both experiments.

b) Optimization of Variable Response to Hardness

Optimization variables for the hardness response (was performed using the method of RSM central composite design, where there are 2 factorial design 2 (2) central composite, runs 10 beef meatballs made with the addition of liquid smoke and carrageenan in Table 4.2., And storing sampling for 0, 12, 24, and 36 hours. The percentage increase in the hardness and resilience of each variation compared to the control with the following equation:

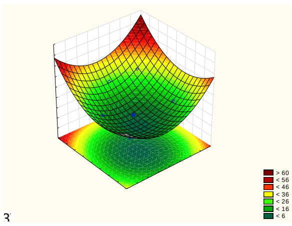
$$\%\ \text{Increase} = \frac{\text{sample value} - \text{control value}}{\text{control value}} \times 100\% \qquad (2)$$

Furthermore, the value of the increase percentation the hardness and springness responses present in Tables 2 and 4.

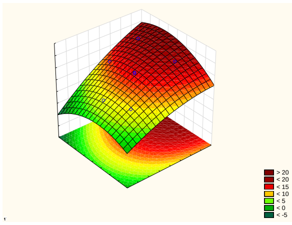
Table 2. Variable Optimization against Hardness Response

Liquid smoke (%)	Carrageenan (%)	Hardness responses (hours)			
		0	12	24	36
0,5	0,5	6.1	8.32	-7.07	23.58
1	0,5	22.32	19.94	-2.59	18.51
0,5	1,5	16.91	5.54	-8.59	46.82
1	1,5	31.51	20.48	9.66	30.01
0,75	1,707	23.73	12.63	-6.41	25.39
0,75	0,293	6.53	8.25	-6.79	21.05
1,103	1	14.17	15.27	1.36	21.11
0,3965	1	20	8.79	12.8	18.94
0,75	1	6.23	14.62	12.52	8.21
0,75	1	7.15	14.3	12.31	8.15

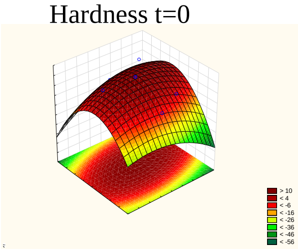
To determine the maximum value of a hardness response, can be seen from the contour plot in each storage time as follows:



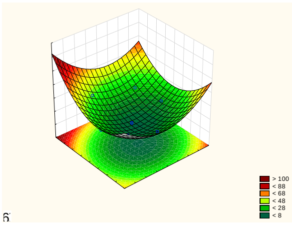
Hardness t=0



Hardness t=12



Hardness t=24



Hardness t=36

Figure 1. Contour plot of the response variable optimization hardness

Contour plots showing the effect of increasing concentration of liquid smoke and carrageenan against a hardness response. From interaction shows that at t = 0, the higher the concentration of liquid smoke and carrageenan were added cause beef meatballs decrease hardness. This means that at t = 0 addition of these variables do not have a significant influence on the response. At t = 12 contour show saddle point condition which means that the point of intersection of maximum and minimum contour. At t = 24 indicates the value of the maximum response with the addition of liquid smoke and carrageenan concentration. Contour minimum recoverable at t = 36. These results show the value of the texture of beef meatballs hardness reached a maximum in storage at t = 24. In addition to contour plots, can be seen also the model equations used were tested by ANOVA analysis and Pareto charts on the maximum value of t = 24. The model equations are used as follows:

$$y = 12.416 + 0.819\, x_1 – 3.265\, x_1{}^2 + 1.409\, x_2 − 10.107\, x_2{}^2 + 3.443\, x_1 x_2 + 0 \quad (3)$$

Where x1: the concentration of liquid smoke; x12: quadratic concentration of liquid smoke; x2: carrageenan concentration; x22: quadratic concentration of carrageenan; x1x2: interaction between the concentration of liquid smoke with carrageenan. To test the model of equation (3) is performed ANOVA analysis as follows:

Table 3. Analysis of Variance (ANOVA) for the hardness response at t = 24

Factor	SS	DF	MF	F-value	p-value
X1 (L)	5.369	1	5.369	0.1001	0.767
X1(Q)	48.708	1	48.708	0.912	0.394
X2 (L)	15.872	1	15.872	0.297	0.615
X2 (Q)	**466.785**	**1**	**466.785**	**8.741**	**0.042**
interaksi X1 & X2	47.403	1	47.403	0.887	0.399
S.S error	213.598	4	53.399		
total S.S	755.381	9			
R^2	0.717				

ANOVA was used to explain any variation statistics obtained from the model equations. The influence of the significance of a factor from Table 3 is obtained from F and p value. p-value is the probability of rejecting the null hypothesis of the research results when the null hypothesis that is actually true, the value of p-value less than 0.05 with an accuracy of 95% indicates that variable significant effect. F-value is the ratio between MSF (Mean Squares of Factor) and MSE (Mean Squares of Error). A factor has a significant influence when the F-value is greater than F-table (Nuryanti and Salimy, 2008). At t = 24, the value of R2 is 0.717 which showed 28.27% of the total variation is not in accordance with the model of equation (4.4). F value of each factor compared with F table (0,05,5,4) = 6.26. Retrieved variables that influence in the model that is quadratic concentration of carrageenan with an F value of 8741 and a probability of 0.042.

The ANOVA data in accordance with Pareto charts, which show the order of variables that affect the model of equation (2).

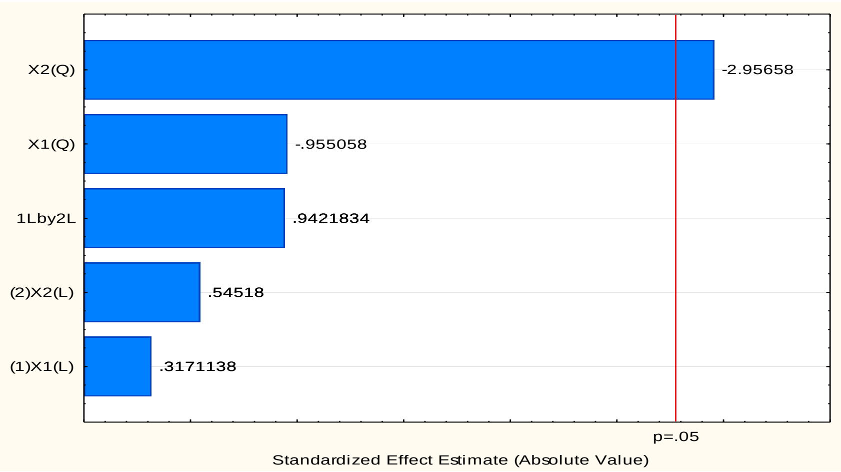


Figure 2. Graph of Pareto optimization of the response variable hardness (hardness) at t = 24

Based on Figure 2 can be seen sequences of hardness factors affecting beef meatballs at t = 24, ie: quadratic concentration of carrageenan, quadratic concentration of liquid smoke, liquid smoke concentration interaction and carrageenan, carrageenan concentration linear, and linear concentration of liquid smoke. Quadratic variable concentrations of carrageenan gives a significant influence on the violent response beef meatballs at t = 24. Although the concentration of liquid smoke and carrageenan are factors that affect the hardness of meatballs, carrageenan gives a greater effect on the response. This is because the carrageenan has binding properties of water and can form a gel upon cooling fragments, and will affect the texture of hardness and springness resulting in processed meat products (Verbecken et al., 2005). This is according to research conducted by Hsu and Chung (2001) that the addition of carrageenan can significantly increase the hardness, springness and cohesiveness in beef meatballs

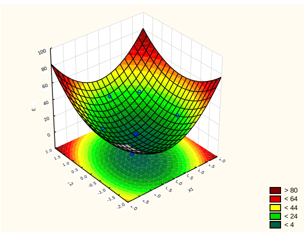
c) ***Optimization of the response variable Springiness***

The percentage of increase value in the springiness was calculated according to the equation (1), then put in Table 4 as follows:

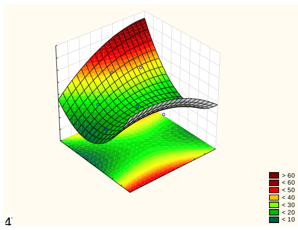
Liquid smoke (%)	Carragenan (%)	Springness respons (hours)			
		0	12	24	36
0,5	0,5	7.14	30.77	6.67	-7.14
1	0,5	28.57	30.77	6.67	-7.14
0,5	1,5	14.29	23.08	0	14.29
1	1,5	28.57	38.46	20	7.14
0,75	1,707	28.57	38.46	13.33	7.14
0,75	0,293	7.14	30.77	6.67	-14.29
1,103	1	21.43	15.38	-26.67	21.43
0,3965	1	28.57	15.38	13.33	7.14
0,75	1	3.21	23.08	33.56	7.14
0,75	1	3.56	23.08	34.75	7.14

Table 4. Variable Optimization of the response springiness

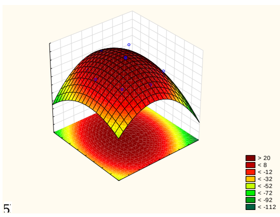
To determine the value of the maximum springness response, can be seen from the contour plot in each storage time as follows:



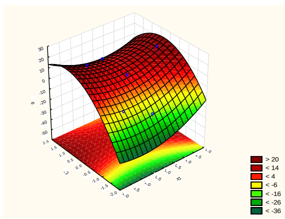
Springness t=0



Springness t=12



Springness t=24



Springness t=36

Figure 3. Contour plot of the response variable optimization springness (springiness)

Contour plots showing the effect of adding liquid smoke and carrageenan concentration to springiness response. From interaction shows that at t = 0, the higher the concentration of liquid smoke and carrageenan were added to cause a decrease in the elasticity of beef meatballs. This means that at t = 0, the addition of these variables do not have a significant influence on the response. At t = 12 contour show saddle point condition which means the point of intersection of maximum and minimum contour. At t = 24 indicates the value of the maximum response with the addition of liquid smoke concentration and carrageenan. Saddle point contour recovered at t = 36. These results show the value of texture elasticity beef meatballs storage reaches a maximum at t = 24.

In addition to contour plots, can be seen the model equations used were tested by ANOVA analysis and Pareto charts on the maximum value of t = 24. The model equations are used as follows:

$$y = 34.153 - 4.571\, x_1 - 18.747\, x_{1^2} + 2.009\, x_2 - 10.410\, x_{2^2} + 5\, x_1 x_2 + 0 \quad (4)$$

To test the model of equation (4) performed ANOVA analysis as follows:

Table 5. Analysis of Variance (ANOVA) for the response springiness at t = 24

Factor	SS	DF	MF	F-value	p-value
X1 (L)	167.104	1	167.104	0.811	0.419
X1(Q)	**1606.039**	**1**	**1606.039**	**7.798**	**0.049**
X2 (L)	32.315	1	32.315	0.157	0.712
X2 (Q)	495.174	1	495.174	2.404	0.196
interaksi X1&X2	100.000	1	100.000	0.486	0.524
S.S error	823.769	4	205.942		
total S.S	2760.864	9			
R^2	0.7016				

Based on Table 5, at t = 24 R2 value of 0.702 was obtained which showed 29.84% of the total variation is not in accordance with the model of equation (4.4). F value of each factor compared with F table (0,05,5,4) = 6.26. Thus obtained variables that influence in the model that is quadratic concentration of liquid smoke with an F value of 7.798 and a probability of 0.049

The ANOVA data in accordance with Pareto charts showing the sequence of variables that affect the model of equation (3).

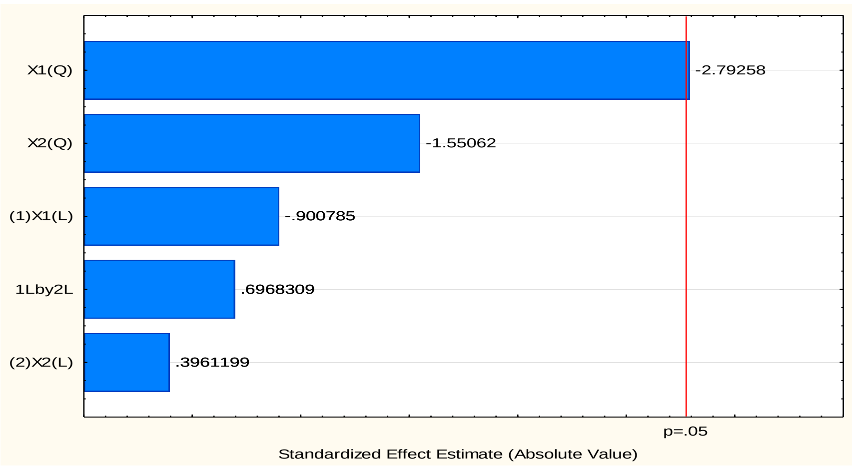


Figure 4. The graph of Pareto optimization variables on the response of springiness at t = 24

Based on Figure 4, it can be seen that the order of the factors that affect the elasticity of beef meatballs at t = 24, ie quadratic concentration of liquid smoke, quadratic concentration of carrageenan, linear concentration of liquid smoke, liquid smoke concentration interaction and carrageenan, as well as the linear concentration of carrageenan. Quadratic variable concentrations of liquid smoke provides a significant effect on the response elasticity beef meatballs at t = 24

Meatballs elasticity associated with the strength of the gel formed by heating. According Basmal (2003), carrageenan if it binds with cations will produce a strong gel and chewy texture. Additionally, carrageenan is able to form a three-dimensional mesh which can trap the water and cause the elasticity increases (Pietrasik and Jarmolouk, 2003)..

d) Determination of Optimum Value Beef Meatballs against Hardness Texture and springness

The optimum condition of beef meatballs on the hardness texture and springness were obtained during 24 hours of storage. To determine the optimum composition of liquid smoke and carrageenan, was done by inserting the optimum value into the equation 1. Optimum composition texture of beef balls can be seen in Table 6.

Table 6. The optimum composition of beef meatballs on the texture

Variable	**The optimum composition (%)**
The concentration of liquid smoke	0,755
The concentration of carrageenan	1.04

e) Brightness Color Levels Analysis

Color is one of the visual nature of the first seen by the consumer. Color has a very important role and can give the impression from people to liked or disliked. The significance and role of color in food products, among others as detailed types, signs of damage, the level of quality and guidance manual processing (Soekarto, 1985).

Color measurement was analized by using a color reader. L is a color parameter value (lightness / brightness level) stating the dark and bright of material. More greater the value of L, more brightr the material. L value ranges between 0 (black) to 100 (white). L value of the beef balls can be seen in Table 7.

Table 7. Beef Meatballs Color Analysis

Liquid smoke (%)	**carrageenan (%)**	**Lightness**			
		0	**12**	**24**	**36**
0,5	0,5	68.42	57.53	53.08	61.88
1	0,5	64.86	61.77	56.26	57.03
0,5	1,5	67.41	63.12	54.46	57.52
1	1,5	64.93	59.77	50.01	50.60
0,75	1,707	65.23	62.98	52.01	53.98
0,75	0,293	65.10	59.55	50.87	53.75
1,103	1	64.42	65.49	50.68	56.68
0,3965	1	64.55	65.55	48.01	56.21
0,75	1	64.06	65.88	62.30	59.86
0,75	1	63.15	71.27	62.44	50.20
0	0	64.81	67.77	54.67	53.13

Based on Table 7, can be seen that the addition of liquid smoke and carrageenan did not give a significant effect on the beef meatballs color. This is because the use of liquid smoke and carrageenan used to improve the texture and can increase the water holding capacity. Additionally, carrageenan which used is white powder and liquid smoke in a clear liquid so does not affect the value of L (brightness) meatballs. However, the storage time to give effect to the value of L. The longer the storage time the smaller the value of L. It is caused by the decay process that occurs during the storage time cause discoloration becomes darker.

SUMMARY

Liquid smoke and carrageenan can be used as an alternative mixture material inbeef meatballs, because it can improve the hardness texture and springness of beef meatballs. The maximum value was obtained at 24 hours storage with optimum concentration of liquid smoke composition at 0.755% and carrageenan concentration at 1.04%. The addition of liquid smoke and carrageenan did not significantly affect to the meatballs colors.

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