International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Investigation for Addition Levels of Sugar, Nitrite and β-carotene on the Optimal Conditions of Pork *Dendeng* on Sensory Attributes by Response Surface Methodology

Alvina Dyah Arumsari[1], Lilik Eka Radiati[1], Wen-Shin Lin[2], Chih-Ming Chen[3]
[1]Department of Animal Science, University of Brawijaya, Malang 65145, Indonesia
[2]Department of Plant Industry, National Pingtung University of Science and Technology, Pingtung 912, Taiwan
[3]Department of Animal Science, National Pingtung University of Science and Technology, Pingtung 912, Taiwan

Abstract— *Dendeng is one of traditional Indonesian jerky and its qualities are influenced by processing and ingredients. Investigation was carried out on pork dendeng development which may be accepted by Taiwanese and Indonesian, due to the factor that dendeng are popular in Asia with multicultural characteristics. Response surface methodology was used to investigate the effect of different addition levels of sugar (18, 24, 30%), nitrite (0, 7.5, 150 ppm) and β-carotene (0, 0.1, 0.2%) on sensory attributes, such as color, texture, aroma, flavor, sweetness, juiciness and overall acceptability. Box-behnken experimental design was used in which 17 different runs with 5 trials of three similar center point. The results in this study were processing variables significantly affected the response variables either linearly or quadratically whereas the Lack of Fit was non-signifant relative to the pure error. This study indicated that optimum value for the responses of pork dendeng prepared by sugar, nitrite and β-carotene can be obtained using 28.55%, 88.51 ppm and 0.10%, respectively. The responses for color, texture, aroma, flavor, sweetness, juiciness and overall acceptability, were predicted at 5.61, 5.23, 4.47, 6.12, 5.10, 5.46 and 5.44 respectively, with a desirability value of 0.68.*

Keywords— *Multi-cultured Characteristic, Nitrite, Pork Dendeng, Response Surface Methodology, Sugar.*

I. INTRODUCTION

The consumptions of sweet snacks have increased as the increasing of multinational companies [1]. The growth of the snack market has been growing rapidly, observed in Asia-Pacific and Latin American countries, compared to other regions [2]. The oldest meat product which has been sold as snack for many years is dried meat, such as jerky [3]. *Dendeng* is Indonesian traditional jerky from Java and Bali Islands, made by basic ingredients such as spices, sugar, salt, and nitrite [4]. Sugar is the most important ingredient in *dendeng* that is added around 33% (16.5 of sugar and 16.5% of brown sugar) [5]. Southeast Asian favor to have greater sweet flavor in chicken dried meat, which used 35% sugar addition level [6]. Whereas, 20 – 24% sugar addition levels in Chinese-style pork jerkies are accepted by Taiwanese [7, 8].

The differences in liking of various sugar content in jerky among different countries, especially Southeast Asia and Taiwan is connected by culture and social identities of people in food consumption. In addition, the number of people from Southeast Asia countries who can afford and are willing to migrate to Taiwan has substantially increased due to globalization trend, transportation and communication technology improvement [9]. The higher migration is resulted from Taiwan becomes new outbound destination, choice and necessity for study abroad for foreign students and job fields [10, 11, 12]. Thus, it has a chance to develop multicultural meat product which can be accepted by Southeast Asian and Taiwanese, because Asian prefer to purchase gifts and souvenirs for relatives and friends during travelling and trips [13].

Jerky color can be affected by drying processing, occurring browning color which is undesirable for some consumers [14]. An extreme color changing of product, even though unaccompanied by change in flavor can make the product unacceptable to consumers [15]. In addition, drying processing of meat is susceptible to peroxidation due to polyunsaturated fatty acids (PUFA) content [16]. Also, drying can reduce the moisture content while reduces water activity which makes harder texture. The use of sugar (humectants) can occur nonenzymatic reactions (Maillard reaction, re-crystallization and caramelization) which plays a crucial role for jerky quality, such as affect the color, flavor and texture [6].

Nitrite is a reactive compound for jerky which has multifunctional roles and commonly added during meat curing [17, 18]. However, the possibility of finding a single compound that can replace and work in accordance with all nitrite functions is quite dim [19]. After all, decrease in nitrite levels is offset by adding synthetic food additives in jerky that can be used to mimic the roles of nitrite, as colorant and an antioxidant, such as β-carotene. β-carotene is the carotenoid compound present in the human diet that can exhibit anticancer and antioxidant properties. The main function of β-carotene is as food coloring additive for an orange red pigment [20].

Thus, it needs to have development of pork *dendeng* using nitrite and β-carotene for color, aroma and flavor improving with higher sugar level expecting to improve pork *dendeng* texture, which may be accepted by Southeast Asian and Taiwanese due to the differences of sweetness likeness. In the present study, response surface methodology (RSM) was used

Alvina Dyah Arumsari, Lilik Eka Radiati, Wen-Shin Lin, and Chih-Ming Chen, "Investigation for addition levels of sugar, nitrite and β-carotene on the optimal conditions of pork *dendeng* on sensory attributes by response surface methodology," *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 306-312, 2021.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

to develop a sweet-pork *dendeng* as well as attractive appearance which can improve sensory attributes, using sugar, nitrite and β-carotene.

II. Materials and Methods

A. Pork Dendeng Preparation and Processing

The material was pork and its ingredients were phosphate 0.2%, salt 2.5%, sucrose as sugar 18, 24, 30%, nitrite 0, 7.5, 150 ppm and β-carotene 0, 0.1, 0.2%. The frozen pork was thawed and cut, then it was grinded using grinder with 9.5 mm plate for coarse grinding) and re-grinded using 3.2 mm plate for fine grinding. The ground pork was mixed with ingredients using mixer at 3.3°C of pork temperature. The mixture of batter was formed to square pieces with a plastic sheet into size 30 × 24 × 0.3 cm^3 in every 300 g of batter. Pork *dendeng* were dried in air dryer at 50°C for 3 h (first stage) and 55°C for 2.5 h (second stage). Pork *dendeng* samples were done to upside down before it dried at second stage. After dried, pork *dendeng* samples were cooked in oven at 180°C for 5 min and cooled down at ambient temperature (25°C). The final products were packaged in vacuum packaging for sensory evaluation.

B. Experimental Design

This study used three-factor-three-level Box-Behnken experimental design with five replicates at the center point which was used to optimized the levels of variables [21]. The design used three levels (low, medium, high and were being coded as -1, 0 and 1). Thus, the total of treatments was 17 different trials and it were carried out in triplicate. Treatments of 17 trials were conducted to select the independent variables levels which were sugar, nitrite, and β-carotene for pork *dendeng* development. Independent variables were denoted as X_1, X_2 and X_3. Independent variables were divided into coded and un-coded values that were obtained from experimental design were shown in Table 1.

TABLE 1. Experimental design matrix that used to evaluate the effects of variables.

Runs	Coded variables			Un-coded variables		
	X_1 (%)	X_2 (ppm)	X_3 (%)	Sugar (%)	Nitrite (ppm)	β-carotene (%)
1	1	0	1	30	75	0.2
2	0	0	0	24	75	0.1
3	0	0	0	24	75	0.1
4	-1	1	0	18	150	0.1
5	0	-1	1	24	0	0.2
6	0	0	0	24	75	0.1
7	-1	-1	0	18	0	0.1
8	1	-1	0	30	0	0.1
9	0	-1	-1	24	0	0
10	-1	0	1	18	75	0.2
11	1	0	-1	30	75	0
12	1	1	0	30	150	0.1
13	0	1	1	24	150	0.2
14	0	0	0	24	75	0.1
15	0	1	-1	24	150	0
16	0	0	0	24	75	0.1
17	-1	0	-1	18	75	0

X_1, X_2 and X_3 are coded variables.
Sugar: sucrose.

C. Sensory Evaluation

The panelists for sensory evaluation were 10 Taiwanese and 10 Indonesian students from National Pingtung University of Science and Technology, Taiwan. Pork *dendeng* samples were evaluated using 7-point hedonic scale which was ranging from 1 (dislike extremely) to 7 (like extremely) and it was indicating very low to very high desirability for color, texture, aroma, flavor, sweetness, juiciness and overall acceptability. Pork *dendeng* samples were placed on plates which were tagged using random numbers. The panelists rinsed their mouths using water between sample tasting.

D. Statistical Analysis

All data were analysed for different responses using Design-Expert (DX) 7.0® software. After conducting the runs, a second order polynomial of the following form was fitted and the data were analysed employing multiple regression technique to develop a response surface model. The optimum points were calculated according to the following equation.

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i X_i + \sum_{i=1}^{3} \beta_{ii} X_i^2 + \sum_{i=1}^{2} \sum_{j=i+1}^{3} \beta_{ij} X_i X_j + E$$

From the equation, Y is the estimated response, β_0 represents the intercept, and β_i, β_{ii}, and β_{ij} are the coefficients for the linearity, quadratic and interaction, respectively. X_i and X_j (i=1–3, j=1–3 and i≠j) are defined as the coded independent variables. E means the residual error. The equation expresses the relationship between the predicted response and independent variables in coded values. The F-values, R^2 values and CV were computed for all responses. Several responses surface in 3-dimensional surface graphs were drawn to show the effect of two variables on each response, by imposing a constant value equal to mid-level of third variable. The effect of the independent variables individual responses was described at $P < 0.05$ level of significance [22, 23].

III. Results and Discussion

The development of pork *dendeng* were using RSM Box-Behnken experimental design with maximum points possible number. The three factors and seven responses of sensory evaluation, color, texture, aroma, flavor, sweetness, juiciness and overall acceptability are shown in Table 2. The selected responses influenced the sensory quality of pork *dendeng* and their values depended on the three factors chosen for the present design. This study was found that all the responses with F-values for the model were significant ($P < 0.05$) and all of the lacks of fit tests were not significant ($P > 0.05$) which showed the experimental data and the model validation (Table 3). The experimental responses and 3-D surface plot for all sensory attributes of pork *dendeng* are shown in Figure 1 – 3, respectively. The R^2 value reflects the suitability of the model to represent the real relationship between the selected reaction parameters. The model was checked by R^2, adjusted R^2 and coefficient of variance (CV) [24]. The result of this study indicated that optimum value for the responses of pork dendeng treated with combination among sugar, nitrite and β-carotene addition levels can be obtained using 28.55%, 88.51 ppm and 0.10%, respectively. The responses for color, texture,

Alvina Dyah Arumsari, Lilik Eka Radiati, Wen-Shin Lin, and Chih-Ming Chen, "Investigation for addition levels of sugar, nitrite and β-carotene on the optimal conditions of pork *dendeng* on sensory attributes by response surface methodology," *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 306-312, 2021.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

aroma, flavor, sweetness, juiciness and overall acceptability, were predicted at 5.61, 5.23, 4.47, 6.12, 5.10, 5.46 and 5.44 respectively, with a desirability value of 0.68.

TABLE 2. Second order design matrix of the effects of process variables and values of experimental responses of pork *dendeng*.

Runs	Coded variables			Un-coded variables			Response						
	X_1 (%)	X_2 (ppm)	X_3 (%)	Sugar (%)	Nitrite (ppm)	β-carotene (%)	Color	Texture	Aroma	Flavor	Sweetness	Juiciness	OA
1	1	0	1	30	75	0.2	5.23	4.73	4.52	5.47	4.00	4.30	5.29
2	0	0	0	24	75	0.1	5.73	4.77	4.59	5.41	4.47	4.00	5.14
3	0	0	0	24	75	0.1	6.83	5.50	4.57	6.27	5.05	5.80	6.18
4	-1	1	0	18	150	0.1	5.05	3.70	4.63	4.86	3.17	3.00	4.27
5	0	-1	1	24	0	0.2	4.38	3.90	3.52	4.43	3.60	3.45	3.98
6	0	0	0	24	75	0.1	5.60	5.57	4.86	6.21	5.90	5.57	5.50
7	-1	-1	0	18	0	0.1	4.07	3.53	3.57	4.15	3.47	3.47	4.35
8	1	-1	0	30	0	0.1	4.82	4.10	3.68	5.28	4.00	4.22	4.53
9	0	-1	-1	24	0	0	4.60	4.03	3.90	5.10	4.30	4.27	4.58
10	-1	0	1	18	75	0.2	4.80	4.13	3.80	5.18	4.40	4.32	4.54
11	1	0	-1	30	75	0	5.24	5.72	4.24	5.97	5.10	5.55	5.21
12	1	1	0	30	150	0.1	5.97	5.61	4.96	6.80	5.50	5.95	6.25
13	0	1	1	24	150	0.2	3.53	4.05	3.07	4.81	4.37	4.00	4.37
14	0	0	0	24	75	0.1	4.47	3.93	3.46	4.07	3.47	3.47	3.64
15	0	1	-1	24	150	0	4.90	4.48	3.82	5.26	4.57	4.45	4.58
16	0	0	0	24	75	0.1	4.97	4.37	3.88	5.18	4.20	4.50	4.57
17	-1	0	-1	18	75	0	4.33	4.90	3.20	4.62	4.67	4.00	4.42

X_1, X_2 and X_3 are coded variables.
OA: Overall acceptability.
Sugar: Sucrose.

TABLE 3. Significant of the regression models (F values) and the effects of processing variables on pork *dendeng*.

Source of variance	Color R^2 = 0.686 F value	Texture R^2 = 0.831 F value	Aroma R^2 = 0.937 F value	Flavor R^2 = 0.997 F value	Sweetness R^2 = 0.904 F value	Juiciness R^2 = 0.990 F value	Overall acceptability R^2 = 0.988 F value
Linear							
β_1	17.25[a]	63.47[a]	30.32[a]	2041.92[a]	119.94[a]	666.96[a]	424.77[a]
β_2	10.43[a]	0.05	57.18[a]	321.52[a]	0.42	0.40	97.65[a]
β_3	0.79[a]	0.17	0.08	4.26	2.57	2.24	14.00[a]
Cross product							
β_{12}	-	-	1.05	0.11	-	11.14[a]	3.00
β_{13}	-	-	0.59	8.04	-	0.70	1.75
β_{13}	-	-	0.20	4.26	-	1.33	0.18
Quadratic							
β_{11}	-	-	13.45[a]	48.76[a]	-	25.38[a]	17.35[a]
β_{22}	-	-	1.05	13.01[a]	-	7.83	0.53
β_{33}	-	-	0.59	0.36	-	2.40	12.36[a]
Lack of fit	17.13	3.70	14.19	0.33	1.61	1.36	48.16
C.V	9.71	7.18	5.51	1.16	5.80	2.97	2.47
Total model	9.49[a]	21.23[a]	11.62[a]	272.12[a]	40.98[a]	79.63[a]	63.78[a]

$P < 0.05$; R^2—Coefficient of determination.
[a]Significant ($P < 0.05$)

Color

Pork *dendeng* color attribute in this study ranged from 3.53 to 6.80. The equation generated relating dependent variable color and three independent variables (sugar, nitrite and β-carotene) as under,

$$Color = 4.97 + 0.71X_1 + 0.55X_2 + 0.15X_3$$

It was seen from the above equation that the effect of sugar, nitrite and β-carotene addition levels gave rise to linear effect only. The Pred R-Squared of 0.36 is not as close to the Adj R-Squared of 0.61 as one might normally expect and it may indicate a large block effect. The color of pork *dendeng* increased linearly as increasing sugar, nitrite and β-carotene levels. At the middle levels of sugar (24%), nitrite (75 ppm) and β-carotene (0.10%), color of pork *dendeng* was improved.

Pork *dendeng* stimulated desirable gold brownish color formation, connected with nonenzymatic browning reaction which occurring during thermal processing (drying and roasting) and the contribution of β-carotene as an orange pigment additive. Previous studies have reported that sugar (sucrose) might be hydrolyzed to glucose and fructose during processing (drying), so it led nonenzymatic browning reaction in meat products [25, 26].

Color improving effect of nitrite addition on pork *dendeng* can be attributed to the its ability as cured red color. Nitrite pigment for uncooked and cooked cured color is nitrix oxide myoglobin with nitric oxide haemoglobin and nitric oxide

Alvina Dyah Arumsari, Lilik Eka Radiati, Wen-Shin Lin, and Chih-Ming Chen, "Investigation for addition levels of sugar, nitrite and β-carotene on the optimal conditions of pork *dendeng* on sensory attributes by response surface methodology," *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 306-312, 2021.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

myochrome pigment denaturation, respectively [27]. Nitrite cured meat color developed in some complicated series reactions until nitric oxide (NO)-myoglobin formed [28]. NO-myglobin developed stable cured color (nitrosyl-hemochromogen) during thermal processing (drying), but stable cured color will be faded upon exposure to ultraviolet light (UV).

The highest level of sugar, nitrite and β-carotene decreased color attribute scores, it may due to the factors that Maillard reaction had greater effect which resulting darker brown color during drying processing and the nitrite cured color may not appeared stronger.

Texture

The scores of pork *dendeng* texture attribute ranged from 3.53 to 5.72. The following equation was found to fit with the three variables as per linear model for the texture and the equation predicting effect of processing variables is as follows,

$$Texture = 4.53 + 0.92X_1 + 0.026X_2 + 0.047X_3$$

A significant linear effect ($P < 0.05$) of sugar addition levels was found on texture of pork *dendeng* from above equation. Sugar addition levels linearly increased texture score attribute of pork *dendeng*. Sugar improved texture quality of pork *dendeng* due to nonenzymatic browning reaction, such as Maillard reaction and crystallization. The recent study reported that protein cross-linking from Maillard reaction influenced texture of foods [29]. Protein transition is linked with surface cavities which has bulky solute molecules and it can be increased by sugar.

Aroma

Aroma attribute scores of pork *dendeng* ranged from 3.20 to 4.96. The response surface analysis demonstrated a high coefficient of determination ($R^2 = 0.94$) showed the aroma and independent variables. It was found to fit by the following equation,

$$Aroma = 3.82 + 0.43X_1 + 0.59X_2 - 0.023X_3 - 0.11X_{12} - 0.085X_{13} - 0.050X_{23} + 0.40X_{11} + 0.11X_{22} - 0.083X_{33}$$

A quadratic effect was found on sugar addition levels ($P < 0.05$). In addition, sugar and nitrite addition levels had significant linear effects ($P < 0.05$). It indicated sugar and nitrite addition levels improved aroma of pork *dendeng*. The Model F-value of 11.62 implies the model is significant. There is only a 0.19% chance that a ‘‘Model F-Value’’ this large could occur due to noise.

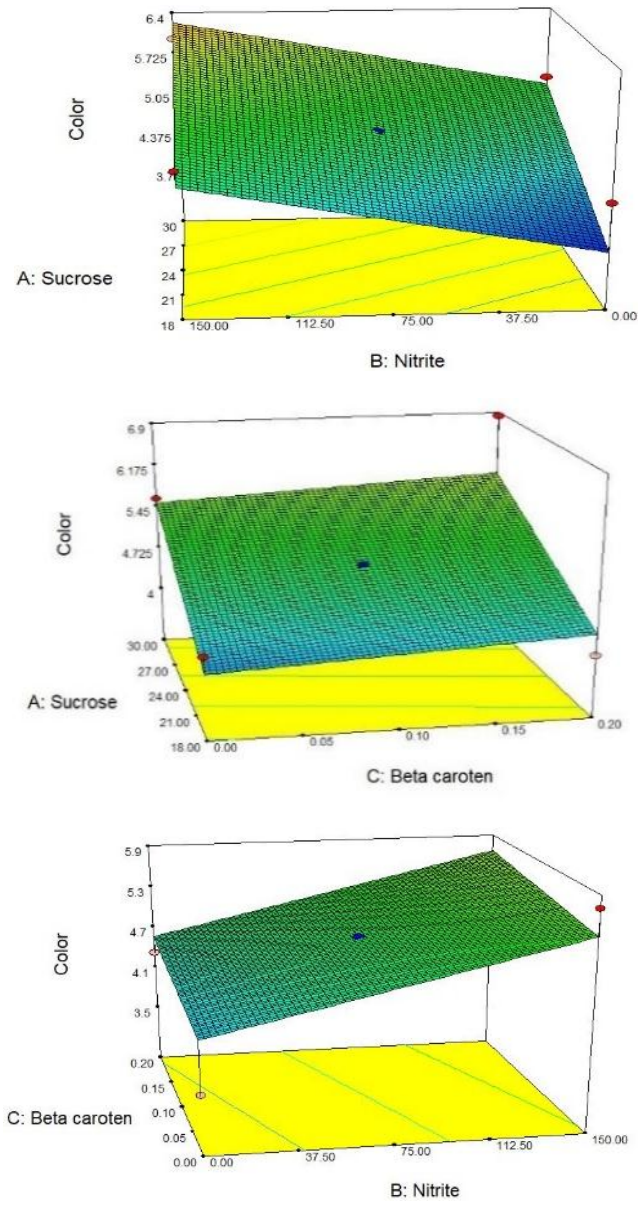

Fig. 1. The surface plot for color.

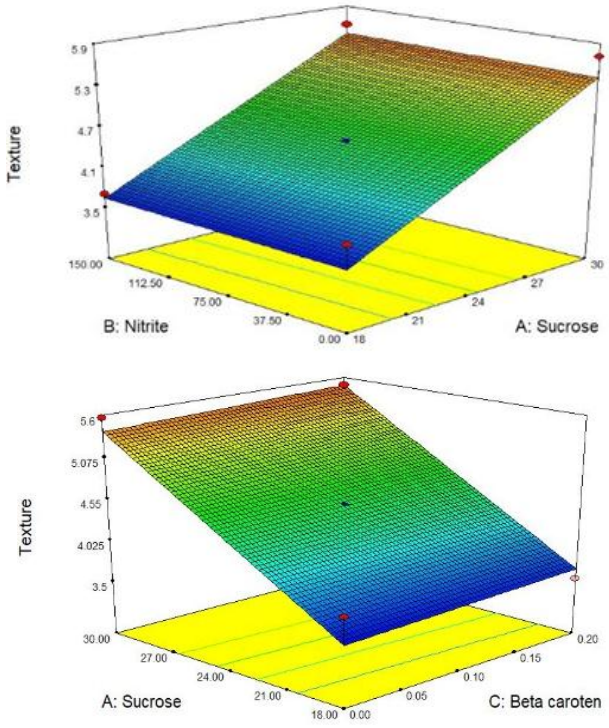

Fig. 2. The surface plot for texture.

Alvina Dyah Arumsari, Lilik Eka Radiati, Wen-Shin Lin, and Chih-Ming Chen, “Investigation for addition levels of sugar, nitrite and β-carotene on the optimal conditions of pork *dendeng* on sensory attributes by response surface methodology,” *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 306-312, 2021.

International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

Pork *dendeng* might have sweet and caramel aroma which occurred during thermal processing (drying). Maillard reaction products may contribute for aroma, connected with formation of volatile compounds [29]. Nitrite may improve aroma by retarding rancidity and over warmed aroma during thermal processing (drying and roasting) [30, 31].

Flavor

The response surface analysis demonstrated a high coefficient of determination (R^2 = 0.10) showed the relationship between flavor and independent variables as follows. It was found to fit with the three independent variables as per quadratic model that explained by the following equation,

$$Flavor = 5.20 + 0.97X_1 + 0.38X_2 - 0.044X_3 + 0.010X_{12} + 0.086X_{13} + 0.062X_{23} + 0.21X_{11} + 0.018X_{22} - 0.14X_{33}$$

It shows that sugar and nitrite addition levels had linear and quadratic effects. Sugar and nitrite addition significantly improved flavor of pork *dendeng* ($P < 0.05$). Sugar contribution on pork *dendeng* flavors may resulted from Maillard reaction which produces desirable flavor. The recent study reported that degradation of sugar products contribute for improving flavor [32].

In addition, another study reported that the increase of nitrite concentration (from 0 to 156 mg/kg) could significantly improve flavor of frankfurters [33]. It may due to the factor that nitrite has antioxidant agent or with another ingredient's combination. However, the principle for unique cured flavor from nitrite is still not clear [34].

Sweetness

It was found to fit with the three variables as per linear model and the equation predicting effect of processing variables is as follows:

$$Sweeteness = 4.37 + 0.98X_1 - 0.058X_2 - 0.14X_3$$

The above equation shows that linear term of sugar had significant effect on the sweetness attribute of pork *dendeng* ($P < 0.05$). Sweetness of pork *dendeng* increased linearly with sugar addition levels. However, lack of fit of sweetness attribute was not significant.

Several researchers have reported the effect of sugar (sucrose) on the sweetness of meat products with different nationality of consumers. An addition of sucrose level by 35% in dried chicken meat had highest sweetness score for consumers from Thailand, because sucrose was not too sweet compared with other sugars. Consumers from Thailand prefer high palatable sweet flavor [6]. As opposed to above study, 24% sucrose addition level on pork jerky tended to reduce the sweetness score for Taiwanese [7]. In addition, another study reported that Taiwanese prefer 20% sucrose addition level in pork jerky. Thus, this model indicated that Southeast Asian and Taiwanese could accept the higher level of RGD sucrose addition level [8].

Juiciness

In the study juiciness attribute scores of pork *dendeng* ranged from 3.00 to 5.80. It found to fit with the three variables as per linear model and the second-order polynomial equation predicting effect of processing variables is as follows,

$$Juiceness = 4.35 + 1.19X_1 + 0.029X_2 + 0.069X_3 + 0.22X_{12} + 0.054X_{13} + 0.075X_{23} + 0.32X_{11} - 0.18X_{22} - 0.098X_{33}$$

The analysis of variance showed that sugar had linear and quadratic effects on juiciness of pork *dendeng* ($P < 0.05$). Juiciness attribute of pork *dendeng* decreased as increasing sugar addition levels. Juiciness attribute has relationship with moisture of pork *dendeng*. Pork *dendeng* with higher moisture content tended to had juicer pork dendeng than lower moisture content. Sugar (sucrose) in pork *dendeng* may appeal to water to itself and might be bound chemically as water bound, thus it had potential to reduce the moisture content due to aberration of water content [35].

Overall Acceptability

Overall acceptability (OA) of pork *dendeng* was found to have quadratic relationship with the three process variables as per the following equation,

$$OA = 4.56 + 0.86X_1 + 0.41X_2 + 0.16X_3 + 0.10X_{12} + 0.078X_{13} + 0.025X_2 + 0.24X_{11} + 0.042X_{22} + 0.20X_{33}$$

Linear effects of sugar, nitrite and β-carotene were found to be significant on overall acceptability of pork *dendeng* ($P < 0.05$). However, significant quadratic effects of sugar and β-carotene were found ($P < 0.05$). Increasing sugar levels with increasing nitrite and β-carotene levels up to certain extent increased overall acceptability of pork *dendeng*.

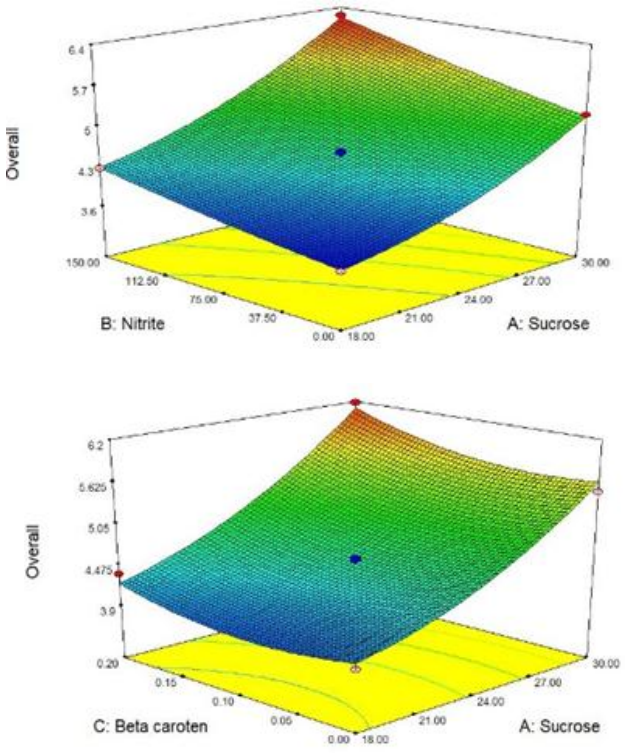

Fig. 3. The surface plot for overall acceptability.

Alvina Dyah Arumsari, Lilik Eka Radiati, Wen-Shin Lin, and Chih-Ming Chen, "Investigation for addition levels of sugar, nitrite and β-carotene on the optimal conditions of pork *dendeng* on sensory attributes by response surface methodology," *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 306-312, 2021.

Some studies observed that Southeast Asian favor to high palatable sweet flavor. Sucrose addition levels from 21% to 24% improved the quality of pork jerky, resulting in higher score of color, aroma, texture, flavor and overall acceptability attributes, which be accepted by Taiwanese [6, 7]. The recent study reported that the highest additions levels of kiwi and pineapple (humectant) had highest overall acceptability scores, due to low SFV and high in tenderness of restructured pork jerky [36]. In addition, another study reported that the addition nitrite at minimum level of 50 ppm was necessary to achieve reasonably typical flavor and appearance characteristic of thuringer sausage [37]. The main nitrite functions in cured meat are developing color characteristic (reddish-pink color) and unique cured flavor, also serving antioxidant and antimicrobial agent alone or with another ingredient's combination [34, 38].

Results indicate that sugar, nitrite and β-carotene effectively develop color, texture, aroma, flavor, sweetness, juiciness and overall acceptability. The unique flavor, sweetness and golden-orange-brown color resulting from sugar, nitrite and β-carotene addition levels played a positive role in the sensory evaluation of pork *dendeng*.

IV. Conclusions

Results concluded that pork *dendeng* can be well prepared using the response surface methodology to identify the best combination of the sugar, nitrite and β-carotene levels for the unique-sweet flavor and attractive color. The pork *dendeng* sensory evaluation shows that sugar, nitrite and β-carotene with 28.55%, 88.51 ppm and 0.10% levels had a highest acceptance. This study suggests that pork *dendeng* may be a multicultural product for Southeast Asian and Taiwanese depending on the people perceptions.

Acknowledgment

The funds and facilities to carry out this experiment were provided by Meat Lab, NPUST. Great thank to all member Meat Lab, NPUST for assisting to pork *dendeng* producing.

References

[1] Bleich, S. N., and J. A. Wolfson, "U.S. adults and child snacking patterns among sugar sweetened beverage drinkers and non-drinkers," *Prev. Med.*, vol. 72, pp. 8-14, 2015.

[2] Kumar, P., A. K. Verma, D. Kumar, P. Umaraw, N. Metha, and O. P. Malav, "Meat snack: a novel technological perspective," Elsevier Inc., pp. 293-321, 2019.

[3] Konieczny, P., J. Stangierski, and J. Kijowski, "Physical and chemical characteristics and acceptability of home style beef jerky," *Meat Sci.*, vol. 76, pp. 253-257, 2007.

[4] Bintoro, P., J. I. Morita, K. Mikawa, and T. Yasui, "Chemical and microbiological analyses of an Indonesian dried beef: dendeng sapi," *J. Fac. Agr. Hokkaido*, vol. 63, pp. 287-292, 1987.

[5] Suryati, T., M. Astawan, H.N. Lioe, T. Wresdiyati, and S. Usmiati, "Nitrite residue and malonaldehyde reduction in dendeng — Indonesian dried meat — influenced by spices, curing methods and precooking preparation," *Meat Sci.*, vol. 96, pp. 1403-1408, 2014.

[6] Wongwiwat, P., and S. Wattanachant, "Effect of sugar types on physical attributes and crystalline structure of sweet-dried chicken meat product," *Int. Food Res.*, vol. 21, pp. 2285-2291, 2014.

[7] Chen, M. C., and H. T. Lin, "Supplementary effects of higher levels of various disaccharides on processing yield, quality properties and sensory attributes of Chinese - style pork jerky," *Asian-Aust. J. Anim. Sci.*, vol. 30, pp. 1773-1783, 2017.

[8] Chen, W. S., D. C. Liu, and M. T. Chen, "Effects of high level of sucrose on the moisture content, water activity, protein denaturation and sensory properties in Chinese-style pork jerky," *Asian-Aust. J. Anim. Sci.*, vol. 15, pp. 585-590, 2002.

[9] Tsay, C. L. J., "Migration between Southeast Asia and Taiwan: trends, characteristics and implications," *Asian Stud.*, vol 3, pp. 68-92., 2015.

[10] Hsu, T. T. K., "A review of Taiwan's old and new go south policy: an economic perspective," *Prospect J.*, vol. 1, pp. 1-19, 2016.

[11] Song, H., and C. H. C. Hsu, "The image of Taiwan as a travel destination: perspectives from mainland China," *J. Travel Tour. Mark.*, vol. 30, pp. 253-271, 2013.

[12] Wang, H. Z., "Transnationalism from below: evidence from Vietnam-Taiwan cross-border marriages," *Asian Pac. Migr. J.*, vol. 21, pp. 291-316, 2012.

[13] Kong, W. K., and T. Z. Chang, "Souvenir shopping, tourist motivation, and travel experience," *J. Qual. Assur. Hosp. Tour*., vol. 17, pp. 163-177, 2016.

[14] Turkmen, N., F. Sari, and Y. S. Velioglu, "Effects of extraction solvents on concentration and antioxidant activity of black and black mate tea polyphenols determined by ferrous tartrate and Folin–Ciocalteu methods," *Food Chem.*, vol. 99, pp. 835-841, 2006.

[15] Yeh, J. Y., R. D. Phillips, A V. A. Resurreccion, and Y. C. Hung, "Physicochemical and sensory characteristic changes in fortified peanut spreads after 3 months of storage at different temperatures," *J. Agric. Food Chem.*, vol. 50, pp. 2377-2384, 2002.

[16] Wiklund, E., J. Pickova, S. Sampels, and K. Lundstrom, "Fatty acid composition of M. longissimus lumborum, ultimate muscle pH values and carcass parameters in reindeer (Rangifer tarandus tarandus L) grazed on natural pasture or fed a commercial feed mixture," *Meat Sci*., vol. 58, pp. 293–298, 2001.

[17] Govari, M., and A. Pexara, "Nitrates and Nitrites in meat products," *J. Hellenic Vet. Med. Soc*., vol. 66, pp. 127-140, 2015.

[18] Liu, D. C., S. W. Wu, and F. J. Tan, "Effects of addition of anka rice on the qualities of low-nitrite Chinese sausages," *Food Chem*., vol. 118, issue 2, pp. 245-250, 2010.

[19] Shahidi, F., and R. B. Pegg, "Nitrite-free meat curing systems: update and review," *Food Chem*., vol. 43, pp. 185-191, 1992.

[20] Radomska, L. B., and J. Harasym, "β-Carotene—properties and production methods," *Food Qual. Saf*., vol. 2, pp. 69-74, 2018.

[21] Box, G. E. P., and D. W. Behnken, "Some new three level designs for the study of quantitative variables," *Technometrics*, vol. 2, pp. 455-475, 1960.

[22] Arya, A., S. K. Mendiratta, T. P. Singh, R. Agarwal, and S. K. Bharti, "Development of sweet and sour chicken meat spread based on sensory attributes: process optimization using response surface methodology," *J. Food Sci. Technol*., pp. 1-9, 2017.

[23] Bai, Y., G. Saren, and W. Huo, "Response surface methodology (RSM) in evaluation of the vitamin C concentrations in microwave treated milk," *J. Food Sci. Technol*., vol. 52, pp. 4647-4651, 2015.

[24] Myers, R. H., and D. C. Montgomery, "Response surface methodology," in *Process and product optimization using designed experiments*, John Wiley & Sons Inc, New York, pp. 297–340, 1995.

[25] Schoebel, T., S, R, Tannenbaum, and T. P. Labuza, "Reaction at limited water concentration," *J. Food Sci*., vol. 34, pp. 324-329, 1969.

[26] Karel, M., and T. P. Labuza, "Nonenzymatic browning in model systems containing sucrose," *Food Sci Nutr*., vol. 16, pp. 717-719, 1968.

[27] MacDougall, D. B., D. S. Mottram, and D. N. Rhodes, "Contribution of nitrite and nitrate to the colour and flavor of cured meats," *J. Sci. Food Agri*., vol. 26, pp. 1743-1754, 1975.

[28] Sebranek, J., "Basic curing ingredients," in *Ingredients in Meat Product*, in Tarte, R., Ed. Springer Science, New York, 2009.

[29] Starowicz, M., and H. Zielinski, "How Maillard reaction influences sensorial properties (color, flavor and texture) of food products?" *Food Rev. Int*., vol. 35, pp. 707-725, 2019.

[30] Parthasarathy D. K., and N. S. Bryan, "Sodium nitrite: The "cure" for nitric oxide insufficiency," *Meat Sci*., vol. 92, pp. 274-279, 2012.

[31] Pegg, R. B., and F. Shahidi, "Cured meat products and residual nitrite cured meats and n-nitrosamines benefits and drawbacks of nitrite: new trends and prospects references," Willey-Blackwell, pp. 1-5, 2000.

[32] Pons I., C. Garrault, J. N. Jaubert, J. Morel, and J. C. Fenyo, "Analysis of aromatic caramel," *Food Chem*., vol. 39, pp. 311–320, 1991.
[33] Sebranek, J. G., B. G. Schroder, R. E. Rust, and D. G. Topel, "Influence of sodium erythorbate on color development, flavor and overall acceptability of frankfurters cured with reduced levels of sodium nitrite," *J. Food Sci*., vol. 42, pp. 1020-1021, 1977.
[34] Sindelar, J. J., and A. L. Milkowski, "Sodium nitrite in processed meat and poultry meats: a review of curing and examining the risk/benefit of its use," *AMSA*., vol. 3, pp. 1-14, 2011.
[35] Sorapukdee, S., C. Uesakulrungrueng, and K. Pilasombut, "Effects of humectant and roasting on physicochemical and sensory properties of jerky made from spent hen meat," *Korean J. Food Sci. An*., vol. 36, pp. 326-334, 2016.
[36] Kim, G. D., E. Y. Jung, H. W. Seo, S. T. Joo, and H. S. Yang, "Textural and sensory properties of pork jerky adjusted with tenderizers or humectant," *Korean. J. Food Sci. Ani. Resour*., vol. 30, pp. 930-937, 2010.
[37] Dethmers, A. F., and H. Rock, "Effect of added sodium nitrite and sodium nitrate on sensory quality and nitrosamine formation in thuringer sausage," J. Food Sci., vol. 40, pp. 491-495, 1975.
[38] Pegg, R. B., "*Nitrite curing of meat the n-nitrosamine problem and nitrite alternatives*," *Food and Nutrition Press, Inc*., 2004.

Alvina Dyah Arumsari, Lilik Eka Radiati, Wen-Shin Lin, and Chih-Ming Chen, "Investigation for addition levels of sugar, nitrite and β-carotene on the optimal conditions of pork *dendeng* on sensory attributes by response surface methodology," *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 306-312, 2021.