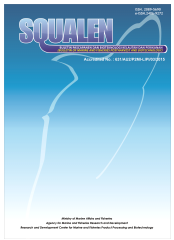

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DETERMINATION AND OPTIMIZATION OF FLOUR FOR PRODUCING CRISPY BABY TILAPIA USING PLACKETT BURMAN DESIGN AND CENTRAL COMPOSITE DESIGN METHOD

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Abstract

Research on processing of crispy baby tilapia (*Oreochromis niloticus*) was conducted to obtain type and proportion of flour on this product with central composite design method. This research used 6 types of flour, namely wheat flour, rice flour, potato flour, tapioca flour, corn flour and baking powder. Baby tilapia used for this research were 30-40 day old, 2-3 cm long. Parameters observed were sensory (appearance, odor, taste, texture, overall acceptance) and crispness for the physical parameter. The results showed that only two out of six variables gave big effect on the tested response i.e potato and rice flour. Those two variables were then optimized with central composite design method to obtain the best product. The optimization process demonstrated that the optimum amount of potato and rice flour were 58-60 g (22.16-22.92%) and 40-60 g (15.28-22.92%), respectively.

Keywords: crispy, tilapia, flour, central composite design, sensory

1. Introduction

One of the commodities from the aquaculture with a good prospective market is small fish called baby fish. Fresh baby tilapia are quite expensive at fish market or supermarket in Jakarta and West Java. Products of baby fish has a high economic value, and its market is still open. Baby fish industry has emerged for over the last 10 years. The fish was intentionally cultivated only for 30-40 days and harvested at size of 2-3 cm long. Cultivation of baby fish also does not need large quantity of feed so it is more economical. Such potential commodity need to be developed since tilapia farming is quite easy.

The development of baby fish aquaculture has been followed by the development of processing industries of baby tilapia both fresh and processed as crispy fried fish. The processing of baby tilapia needs careful and good handling, so that the product is still in good condition when it gets to the consumer, since small-size fish decomposed faster than big fish (Tanaka, Takahashi, Kitazawa & Kimura, 2010).

Besides sold as fresh or frozen fish, baby tilapia can be processed into crispy fried baby fish. Crispy fried baby fish is preferred by consumer because it has a savory flavor, crispy texture, and can be eaten with its bones. Bones of baby fish when fried are still soft and edible, became source of calcium (Suryaningrum et al., 2015). Crispy product in which the crispness is one of the most favorable responses is often associated with the freshness and firmness of natural produced and manufactured food (Tunick et al,. 2013). Szczesniak and Kahn (1984) found that based on interview, Americans considered crispy and crunchy foods to be appealing and enjoyable.

Therefore, it is necessary to provide information related to handling and processing of baby fish either fresh, frozen or fried as well as the formulation of its crispy powder for coating. The purpose of this research is to find type and proportion of flour for crispy baby tilapia. The method of Placket Burman Design (Akhnazarova & Kafarov,1982; Plackett & Burman, 1946) is commonly used to select the variables

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expected to give significant effect to the resulted product. This method statistically can reduce the number of experiments tremendously thus saving time, glassware, chemicals and man-power (Srinivas et al., 1994; Carvalho et al., 1997). In contrary, research and development using conventional method needs more time, money and equiments (Pitta & Pitta, 2012; Thomke & Reinertsen, 2012). Selection was made based on the response given by variables to the expected responses.

Crispy fried baby fish can be cooked with various flours as one of the key factors of the product crispness. There are several flours often used for crispy baby fish production such as tapioca, potato, rice and corn flour. A number of coating materials have been tested, and flour is a major ingredient among them (Kilincceker & Kucukoner, 2007; Yusnita, Aida, Maskat & Aminah, 2007). Mohamed, Abdullah, and Muthu (1989) showed that the crispness of the crackers correlated with the total amylopectin content in the flour. The increase of the crispness is more likely due to the increasing of the overall carbohydrate content of the crackers, hence, the total amylopectin content in the cracker (Nurul, Boni, & Noryati, 2009). The use of tapioca flour for crackers manufacturing could increase the brightness of the final product (Widati, Mustakim, & Indriana, 2011; Susanto & Saneto, 1994; King, 2002; Lavlinesia, 1995). Meanwhile, wheat flour and corn flour can improve the crispness of the product (Agustia, 2009). The combination between rice flour and wheat flour is suggested to improve the texture (crispness) of fish chips (Yusuf, Purwaningsih & Trilaksani, 2012).

This research was carried out using Placket Burman Design (PBD) method followed by Central Composite Design (CCD) method. The purpose of this method is to screen the significant variable to the targeted responses then analyze the effects of the variables on the responses to get the optimum values for attaining the most acceptable product.

2. Material and Methods

2.1. Material

Material used in this study was baby tilapia of 2-3 cm long harvested after 30-40 day cultivation. The flours used were tapioca flour, wheat flour, potato flour, rice flour and baking powder. Other materials used were spices which the quantity is proportional with the amount of flour. Equipment used in this study were deep fryer, spinner, thermometers and scales.

2.2. Methods

2.2.1. Preparation of crispy baby tilapia

Baby tilapia were cleaned from dirt and sand then soaked in 5% brine for 15 minutes. Fish was then drained for 10 minutes and soaked into the six different formula of coating materials. Ratio between coating material and fish was 1 : 1. Fish was mixed with coating material until the surface was fully covered. The coated fish was fried twice, the first frying was performed at 140 °C for 8 minutes and then allowed to cool overnight. The second frying was performed at the same temperature for 7 minutes. Once the second frying completed, the fried fish was put into the 1430 rpm spinner for 2 minutes to remove excess oil.

2.2.2. Experimental design

The research design on crispy baby tilapia was performed in two stages using Minitab 16 Statistical Software, involving PBD for the first stage and CCD for the second stage. Six different flours were set as the variables namely tapioca flour, wheat flour, potato flour, rice flour, baking powder and corn flour. These six variables tested along with their actual levels are given in Table 1. PBD was applied in the experiment, comprised six variables spanning over 14 runs with

Table 1. High and low level values of variables for PBD Test of crispy baby tilapia

Variables	High level (g)	Low level (g)
Tapioca flour	40	10
Wheat flour	150	75
Potato flour	20	10
Rice flour	125	50
Baking powder	2	0.5
Corn flour	40	10

each variable fixed at two levels (low level and high level). Other ingredients were set fixed.

CCD method was applied after the PBD test was completed. The variables used were the significant variables resulted from the PBD test. The purpose of this approach is to optimize the selected variables to produce desirable product.

2.2.3. Texture analysis

Crispy baby fish was analyzed for its crispness using texture analyzer (TA.XT2, Texture Technologies Corp., Scarsdale NY/Stable Micro System, Godalming, Surrey, England).

2.2.4. Sensory analysis

The sensory analysis of the crispy products were evaluated by hedonic test method using 1–7 scale score sheet following SNI 2346 (BSN, 2011). The higher the score, the more acceptable is the product. The attributes of appearance, color, odor, taste, texture and overall acceptance were included in the score sheet. The samples were presented in random order and coded in five digits in small plates. The data for each attribute over the entire experimental were subjected to regression analysis.

3. Results and Discussion

3.1. Screening of Variables by Plackett–Burman Design

A two-level Plackett–Burman factorial design of 12 runs was introduced in this study to unbiasedly screen the important variables that significantly affect the quality of crispy baby tilapia. Table 2 showed the results of experiment using Placket-Burman Design showed that of the six flours used in the crispy baby tilapia processing showed no significant differences for all parameters (Table 3). All the variables used did not give a significant difference to the responses. However, three flours which were baking powder, potato and rice flour gave greater effect to the responses. Baking powder gave negative effects on the most responses while potato and rice flour gave positive effects. The used of baking powder allegedly produced unsmooth surface of the product due to its characteristic producing aerated surface hence decreasing the acceptance of product by panelist. On the other hand, the rice flours are known for its blandness in flavor and desirable white color (Kadan, Bryant, & Pepperman, 2003), therefore preferred by the panelists. The purpose of using various variables in most researches is to produce desirable responses of the products. Thus, due to giving negative effect, baking powder was considered to be neglected for next stage. However, even though the rest two flours did not give a significant difference but its greater effect was considered as the significant variables. Hence, these two variables will go to the next stage for optimization using CCD method.

Influence and interaction between variables and responses can also be seen on the minus notation (-) or plus (+) on the value of effects. Minus indicates that the use of variables will lower the value of the parameter, while the plus indicates that the use of variables will increase the value of the parameter. In this study, for either smell or odor response, greatest effect were resulted from corn flour while for appearance response came from rice flour, taste was from wheat flour, texture from potato flour, overall acceptance was from potato flour and crispness response was produced from baking powder. From all the effect values, rice flour and potato flour have the

Table 2. Variant analysis of crispy baby fish of tilapia

Variables	Parameters											
	Appearance		Odor		Taste		Texture		Overall		Crispness	
	Effect	P Value	Effect	P Value	Effect	P Value	Effect	P Value	Effect	P Value	Effect	P Value
Wheat	0.097	0.535	-0.027	0.911	0.317	0.380	0.478	0.492	0.626	0.243	19.40	0.951
Rice	-0.210	0.206	-0.054	0.825	-0.634	0.634	-0.086	0.900	-0.285	0.577	2830	0.383
Potato	0.070	0.651	0.037	0.880	0.234	0.510	0.700	0.325	0.376	0.466	180.7	0.570
Tapioca	-0.010	0.948	0.116	0.641	0.276	4420	0.514	0.461	0.476	0.363	15.80	0.960
Corn	0.003	0.415	0.226	0.378	0.312	0.387	0.588	0.402	0.453	0.385	-69.50	0.825
Baking Soda	-0.130	0.415	-0.124	0.619	-0,173	0.624	-0.580	0.408	-0.455	0.383	513.2	0.138

Table 3. Variant Analysis of Central Composite Design

Variable	Parameter											
	Appearance		Odor		Taste		Texture		Overall		Crispness	
	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value	Coefficient	P Value
Rice	0.006	0.92	-0.021	0.642	0.017	0.705	0.202	0.062	0.097	0.0002	-0.239	0.443
Potato	-0.092	0.403	-0.011	0.875	0.004	0.949	-0.064	0.659	-0.048	0.720	-0.361	0.480
Rice *Potato	0.001	0.057	0.001	0.190	0.0004	0.401	-0.0007	0.0429	0.0002	0.817	0000	0.990

biggest significant values for all responses compared to other flours so that they were selected as a factorial research for CCD. Due to lower significance and negative effect to all the responses, wheat flour, tapioca flour, corn flour and baking powder were set as fixed value of 112.5 g, 25 g, 25 g, and 1.25 for the next stage of central composite design, respectively.

3.2. Central Composite Design

CCD was employed to study the interactions between the significant variables and also to determine their optimum levels. Two type of flour which produced biggest effect namely rice flour and potato flour were included in this method. Other flours were set fixed based on PBD method. Two levels of flours were set based on their high and low concentration. About 14 experimental runs were executed including 6 runs of center point. CCD aimed to look at the influence of the testing responses. From the results of the PBD, it was known that the variables of rice flour and potato flour provided the greatest impact on testing responses. Based on those effect values and also economic consideration of both type of flours, it was set that the upper and lower limit value of CCD for rice flour and potato flour were 25-75 g and 25-60 g, respectively. Once statistically formulated in terms of CCD, this study obtained 14 formulations in which an observation to sensory characteristics and its physical aspects shall be conducted. Table 3 shows the variant analysis for CCD experiment.

The experimental results showed that the interaction of rice and potato flour provides significant difference on the appearance of crispy baby tilapia (P = 0.057). The use of a single type of flour does not provide significant difference on the observed responses. Greatest value of coefficient obtained from potato variable for parameter of appearance and crispness while parameter of odor, taste, texture and overall opinion were gained from rice. From these data, it is known that the rice flour gives a greater effect than potato flour.

3.2.1 Contour and surface plot

Odor

Contour graph and surface plot of odor parameter can be seen in Figure 1. From the graph it is known that to gain consumer preference level at least 4.8 score (scale 1-7), the crispy baby tilapia should be processed using the combination of rice and potato flour in accordance with the shaded value on the graph.

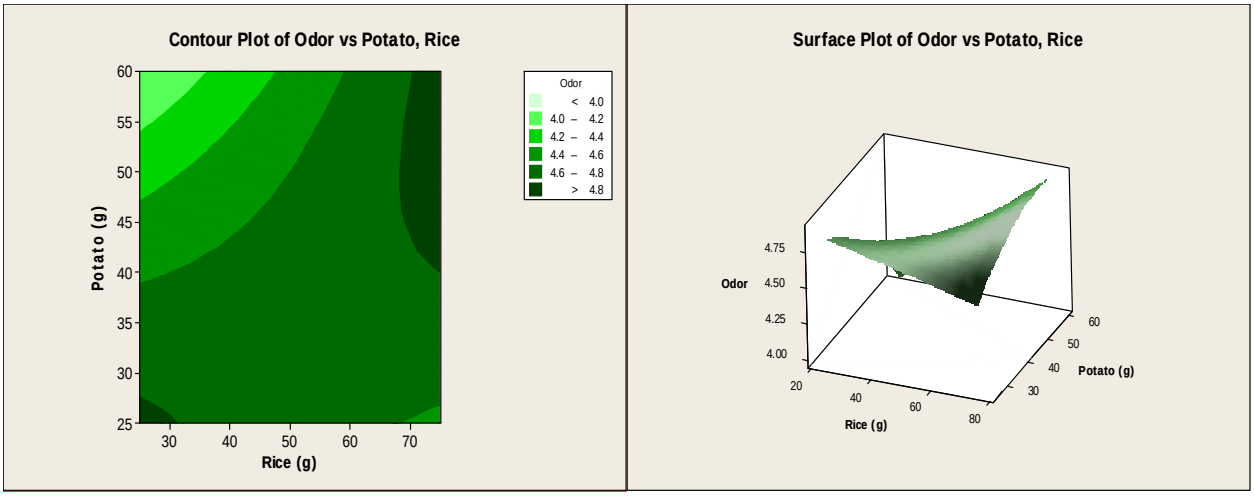

Figure 1. Contour and Surface Plot for Odor of Crispy Baby Tilapia.

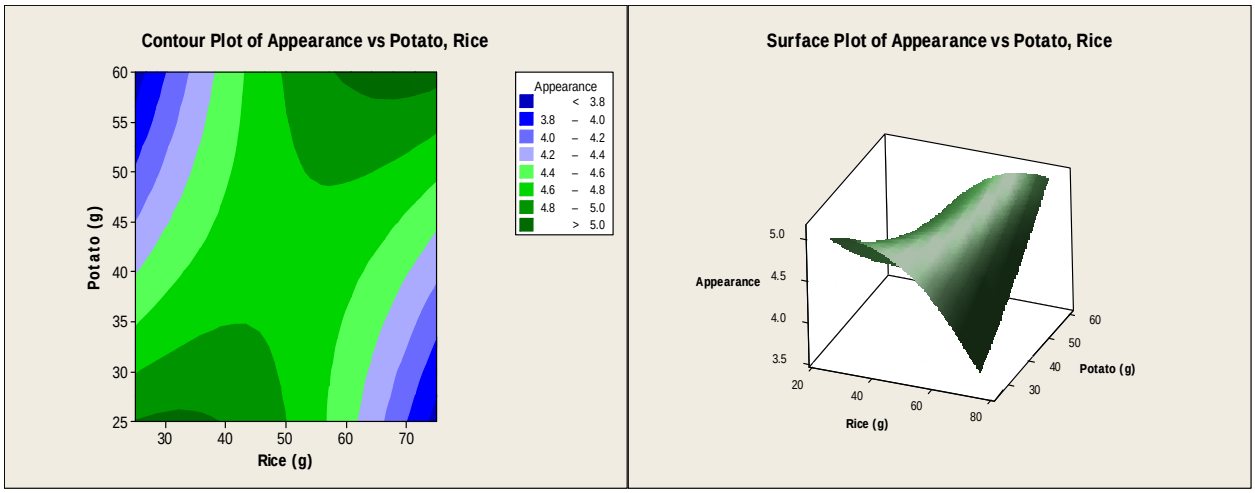

Figure 2. Contour and Surface Plot for Appearance of Crispy Baby Tilapia.

The use of rice flour greater than 68 g and potato flour 40-60 g will produce the level of preference for the smell of more than 4.8. Those values of both variables were accordant with the variant analysis that rice flour gave a positive effect to the panelists' preference.

Appearance

Appearance of crispy baby tilapia using response surface method showed that to produce the product with the preference level above 5 was limited. This was indicated by a dark green shaded area which was very small. However, to obtain a product with value above 4.8 is quite wide open. Value of 4.8 and 5 were not significantly different.

The use of combination between rice flour 30-50 g and potato 25-30 g or combination between rice flour 50-70 g and potato flour 50-60 g in the formula of crispy baby tilapia will provide products with a level of preference for appearance over 4.8 (approaching the like). This is due to the appearance of crispy baby tilapia which is brighter than products with other combinations. The addition of rice flour will increase the brightness level of the product because of the color of the rice itself. In contrast to the rice, addition of potato can lower the brightness level of the product (Noorakmar et al., 2012). Moreover, rice flour has benefit of its blandness in flavor and desirable white color (Kadan et al., 2003) increasing the level of panelists' acceptance. However, because the addition of potato flour is not higher than rice flour, the appearance of crispy baby tilapia remains in the range of panelists' preferences.

Taste

The taste is the most important parameter in developing of new products. Taste contributes greatly to either success or failure of a product on the market. At the experiment of crispy baby tilapia, the rate of

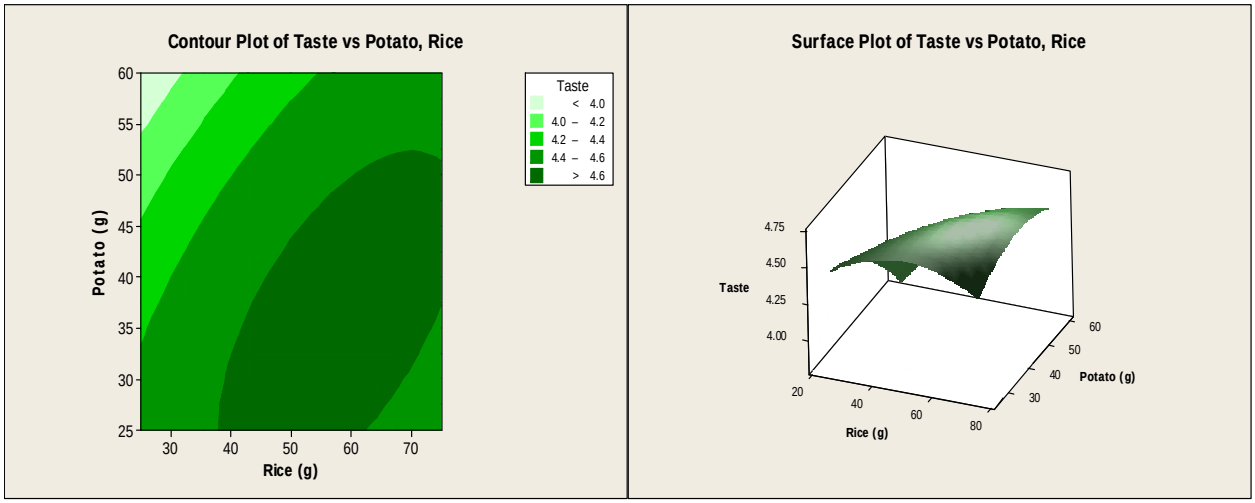

Figure 3. Contour and Surface Plot for Taste of Crispy Baby Tilapia.

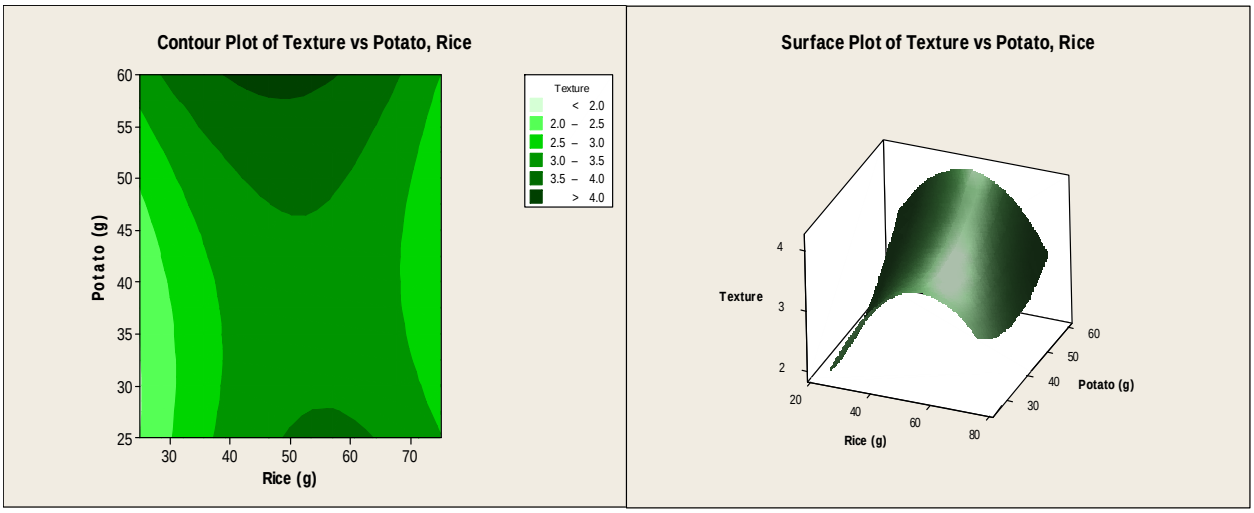

Figure 4. Contour and Surface Plot for Crispness of Crispy Baby Tilapia.

panelists' acceptance at a level approaching like (score 4.8) was obtained by combining potato flour by 25-50 g and rice flour by 40-70 g with slightly modification in accordance with the shaded part as shown in Figure 3. The addition of potato flour by 10-20% was the optimum quantity to increase panelists' acceptance to product substitution of potato flour. At this concentration, potato flour had better effects to the color, odor, and overall acceptability compared to the higher concentration of potato flour (Noorakmar et al., 2012). The recommendation of low amount used of potato is also given in processing of fried fish ball (Syamdidi & Suryaningrum, 2015). Hence, it can be summarized that the addition of potato flour in this study by 25-50 g equals to 10-20% of the total composition is suggested to meet the panelist preference.

Texture

Contour and surface plot for crispness of crispy baby tilapia can be seen in the image of Figue 4. From the results it is known the crispy baby tilapia was scored by around neutral to like (value of 4-5). From the graph, it can be assumed that the level of texture acceptance by panelists can be improved by following the shaded graph for score above 4 (neutral). The combination of rice flour 40-50 g and potato flour less than 25 g increased the value of the panelist's acceptance more than 4 (scale 1-7). The addition of rice flour over 40 g seemed to increase the crispness of the product which is in accordance with Nakamura and Ohtsubo (2014) that found the use of rice flour for tempura snack gave a promising product due to low oil absorption index which leads to crispy product. Rice flour contains high amylopectin which help to increase the crispness (Yusuf et al., 2013). Once the baby fish coated, the water inside the fish will be adsorbed by the formulated flour. The frying process removed the water and at the same time, gelatinization and expansion happened which promote the expansion of the coating flour due to heating process. The use of potato flour in this research did not reduce the crispness significantly due to its low proportion. Noorakmar et al. (2012) reported that the addition of potato flour on extruder product will reduce the level of crispness.

Overall

Overall opinion is an overall response given by panelists without seeing a single attribute of the products tested. In this study, the value of overall opinion for the crispy product was still low means that the product is not worth enough to send into the market. The best value given by the panelist was around 4-5 (neutral-like). Product development using Response Surface Method (RSM) provides an opportunity to improve the quality of products so that the acceptance level of the panelists increases. In this case, acceptance level of panelists can be enhanced using higher proportion of potato flour (over 60 g) while for the rice flour, it ranges from 50-60 g. Other flours were used in accordance with the effect value resulted in PBD. Positive effect means that the variables produce desirable products.

Firmness

Firmness is an important parameter for snack products. Commonly, the crispier the product, the higher the acceptance is. Firmness and crispness is related to water activity (a_w). Increasing the water content of food breaks macromolecular interactions

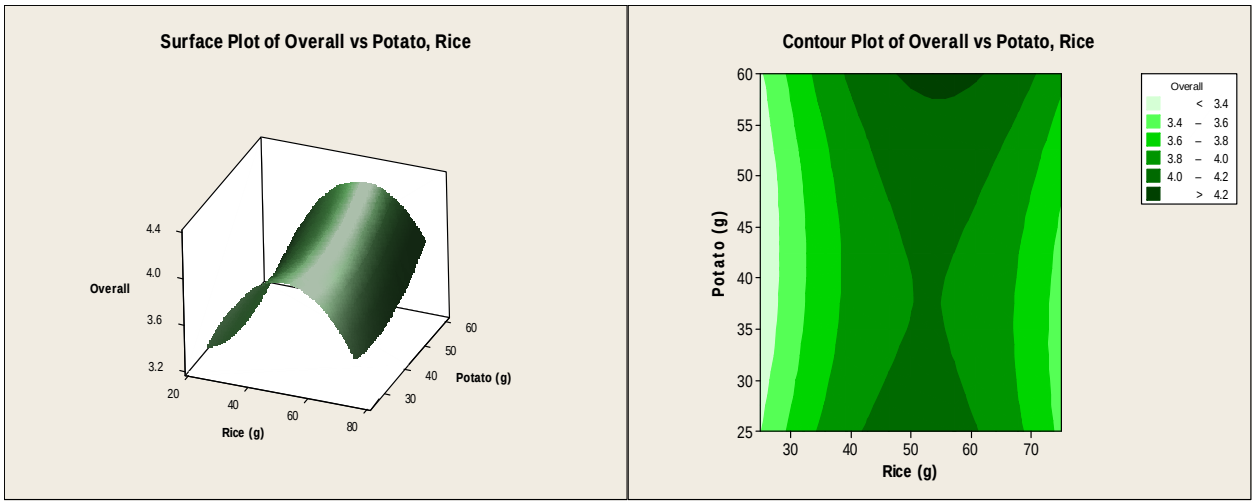

Figure 5. Contour and Surface Plot for Overall Opinion of Crispy Baby Tilapia.

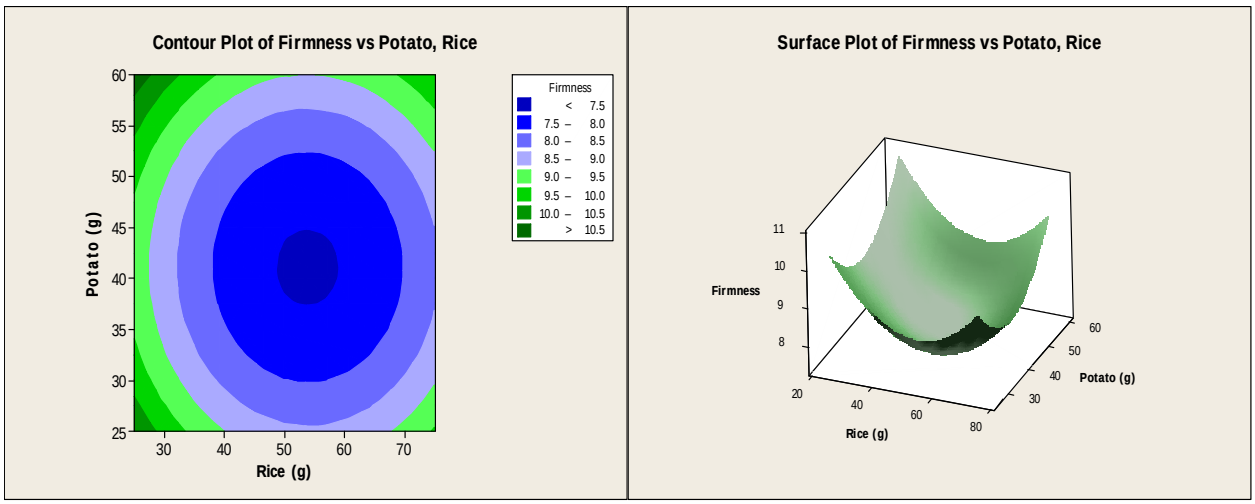

Figure 6. Contour and Surface Plot for Firmness of Crispy Baby Tilapia.

and enhances the mobility of side chains and of sections of the backbone of macromolecules (Tunick et al., 2013).

The highest acceptance of the product crispness was obtained from the combination of rice flour of 40-60 g and potato flour of 40-45 g. The acceptance of the crispness usually correlates with the level of panelists acceptance where the texture is considered not hard (Talahatu, 2011). However, it is not the case with the product of crispy baby tilapia. Panelists tend to prefer products with a medium level of crispness where the texture of the product is not too soft. It is associated with the expectation of panelists where the crispy products will have a medium crunchy texture. The recommended amount of rice flour used was below the high level (75 g) which was 40-60 g in order to produce a medium crisp product. It is known that rice flour contains high amylopectin which help to increase the crispness (Yusuf et al., 2013). Therefore, products made from a combination potato flour of 40-45 g will be preferred by the panelists. The addition of potato flour will increase the hardness of the product (Noorakmar et al., 2012).

Overlay

Overlay response of crispy parameter of tilapia baby fish can be seen in Figure 7. The figure showed the overlay of 5 sensory attributes (appearance, odor, taste, texture and overall opinion). The overlays were determined by the expected value of the panelist's preference which had value above 4 (neutral). The result of this overlay suggested that the acceptable product can be generated by using the scatters value in the white shaded overlay. The amount of rice and potato flour can be generated by putting point in the white shaded area then drawing line to x-axis and y-

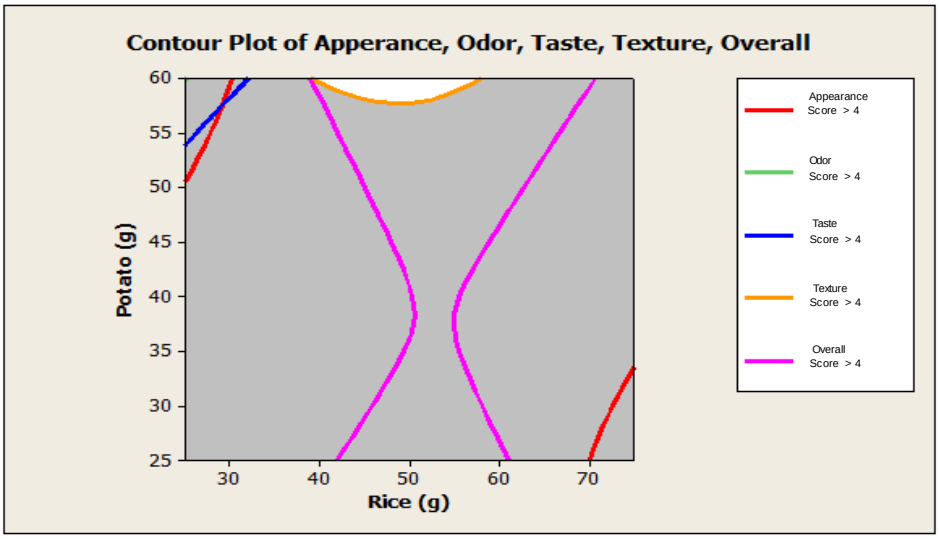

Figure 7. Contour Plot of Sensory Responses of Crispy Baby Tilapia.

axis. Hence, from these experiments, the suggested amount of rice and potato flour were 40-60 g and 58-60 g, respectively. The amount of rice and potato flour can be further developed or higher considering the shading shape resembles a cone facing upwards, meaning that the amount flour can be increased over 60 g for potato and 40-60 g for rice flour.

4. Conclusion

Based on CCD method of analysis, the most suitable flour for crispy coating are potato and rice flour with the optimum proportion of 58-60 g (22.16-22.92%) potato flour and 40-60 g (15.28-22.92%) rice flour. However, further study is still needed to improve product acceptance by the panelists.

References

Agustia, S. (2009). Comparison effect of wheat flour and cornstarch and concentration of agent upon quality of crispy potatoes. *Thesis.* Department of Agriculture Technology. USU, p. 83.

Akhnazarova, S., & Kafarov, V. (1982). Experiment optimization in chemistry and chemical engineering. Moscow: Mir Publication.

BSN. (2011). SNI 2346:2011: Guidance of organoleptic and or sensory testing on fishery products. Jakarta

Carvalho, C.M.L., Serralheiro, M.L.M., Cabral, J.M.S., & Airebarros, M.R. (1997). Application of factorial design to the study of trans esteriûcation reactions using cutinase in AOT-reversed micelles. *Enzyme Microbiol. Technol*. 27:117–123.

Kadan, R.S., Bryant, R.J., & Pepperman, A.B. (2003). Functional properties of extruded rice flours. *Food Chemistry and Toxicology*, 68 (5), 1669-1672.

Kilincceker, O. & Kucukoner, E. (2007). The effect of various coating materials on chicken drumsticks some quality parameters. *Journal of Food Technology*, 5: 279-285.

King, M. A. (2002). Development and sensory acceptability of crackers made from the big-eye fish (*Branchy deuterusauritus*). *Food and Nutrition Bulletin*, 23 (2): 317-340.

Lavlinesia. 1995. Study on some factors of volumetric development and crispness of fish crackers. *Thesis*. Agriculture Institute of Bogor. Bogor.

Mohamed, S., Abdullah, N., & Muthu, M. K. (1989). Physical properties of keropok (fried crisps) in relation to the amylopectin content of starch flour. *Journal of Agriculture and Food Chemistry* 49: 369-377

Nakamura, S. & Ohtsubo, K. (2014). Influence of physicochemical properties of rice flour on oil uptake of tempura frying batter. *Bioscience, Biotechnology, and Biochemistry*. 74:12, 2484-2489.

Noorakmar, A. W., Cheow, C. S., Norizzah, A. R., Mohd Zahid, A., & Ruzaina, I. (2012). Effect of orange sweet potato (*Ipomoea batatas*) flour on the physical properties of fried extruded fish crackers. *International Food Research Journal* 19: 657-664.

Nurul, H., Boni, I., & Noryati, I. (2009). The effect of different ratios of Dory fish to tapioca flour on the linear expansion, oil absorption, colour and hardness of fish crackers. *International Food Research Journal* 16: 159-165

Pitta, D. & Pitta, E. (2012). Transforming the nature and scope of new product development. *Journal of Product & Brand Management*, 21: 35–46.

Plackett, R. L., & Burman, J. P. (1946). The design of optimum multifactorial experiments. *Biometrika*, 33: 305–325.

Srinivas, M.R.S., Naginchand, & Lonsane, B.K. (1994). Use of Plackett–Burman design for rapid screening of several nitrogen sources, growth/ product promoters, minerals and enzyme inducers for the production of alpha-galactosidase by *Aspergillus*

niger MRSS 234 in solid state fermentation. *Bioprocess Eng*. 10: 139–144.

Suryaningrum, T.D., Syamdidi, Ikasari, D., & Muljanah, I. (2015). *Penanganan dan pengolahan baby fish nila*. Penebar Swadaya. Jakarta

Susanto, T. & Saneto, B. (1994). *Technology of agricultural processing*. Bina Ilmu, Surabaya.

Syamdidi & Suryaningrum, T. D. (2015). Screening of significant variables for sliced frying fish ball using Plackett–Burman design. *Squalen Bull. of Mar. & Fish. Postharvest & Biotech*. 10 (1), 9-15.

Szczesniak, A.S. & Kahn, E.L. (1984). Texture contrasts and combinations: A valued consumer attribute. *Journal of Texture Studies*, 15, 285–301.

Talahatu, O. (2011). Study of some physical-chemistry and sensory characteristics of biscuits made of flour mocaf (Modified Cassava Flour). Manado. UNSRAT.

Tanaka, Y., Takahashi, H., Kitazawa, N., & Kimura, B. (2010). Rapid estimation of microbial populations in fish samples by using terminal restriction fragment length polymorphism analysis of 16S rDNA. *Journal of Food Protection* 73:104–113

Thomke, S. & Reinertsen, D. (2012). Six Myths of Product Development. Harvard Business Review. p 8.

Tunick, M.H., Onwulata, C.I., Thomas, A. E., Phillips, J. G., Mukhopadhyay, S., Sheen, S., Liu, C., …… & Cooke, P. H. (2013). Critical evaluation of crispy and crunchy textures: A Review. *International Journal of Food Properties*, 16:5, 949-963

Widati, AS,Widyastuti, ES, Rulita, & Zenny, MS. (2011). The effect of addition tapioca starch on quality of chicken meatball chips with vacuum frying method. *Jurnal Ilmu-ilmu Peternakan*, 21:11 - 27

Yusnita, H., Aida, W.M.W., Maskat, M.Y., & Aminah, A. (2007). Processing performance of coated chicken wings as affected by wheat, rice and sago flours using response surface methodology. *International Journal of Food Science and Technology*, 42: 535-542.

Yusuf, N., Purwaningsih, S., & Trilaksani, W. (2012). Formulasi tepung pelapis savory chips ikan nike (*Awaous melanocephalus*). *JPHPI*, 15(1): 35-44.