Optimization of Production Instant Madura Corn Rice using Response Surface Methodology

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Abstract. Corn commodity in the territory of Indonesia including Madura ranks second after rice. One of Madura's local corn is Talango corn, which has large cobs and a lower setback value compared to other corn. In various regions in Indonesia corn is used as a staple food instead of rice because there are carbohydrates contained in corn. The purpose of this study was to determine the effect of boiling time and calcium hydroxide concentration on the physical, chemical and sensory characteristics of instant Madura corn rice and determine the optimum value and the best composition of instant Madura corn rice. The research method used was Response Surface Methodology with 2 factors, i.e boiling time (20; 30; 40; 50; 60) minutes and calcium hydroxide concentration (0; 0.5; 1; 1.5; 2) %. The results showed that the boiling time and calcium hydroxide concentration did not affect the water content, cooking time and sensory. The optimum value with the best composition is based on sensory characteristics at a boiling time of 60 minutes and a calcium hydroxide concentration of 0% (0 grams) with a desirability value of 0.9087.

1. Introduction
Corn commodity in the territory of Indonesia including Madura ranks second after rice. Most areas of Madura have land suitable for maize cultivation. The distribution of local corn is estimated to be less than 25%, the majority of which is grown in Madura (East Java), East Nusa Tenggara and South Sulawesi [1]. Whereas for corn productivity in Madura according to the Central Statistics Agency in 2017 from several regions in Madura, Sumenep Regency became the highest producer of corn, 325,326 tons, followed by Bangkalan 132,602 tons, Sampang Regency 92,242 tons, Pamekasan District 87,668 tons.

Corn is one of the carbohydrates producing crops other than wheat and rice. For Madurese people, it has always been known as a staple food. Local corn is still the most widely chosen variety. Local maize which is the superior variety in Madura is Talango and Tambin. Talango corn is cultivated in Sumenep Regency. Talango corn has a higher starch content compared to other local corns, 84.53. Talango corn has a lower setback value compared to Tambin corn which is 781 cp while Tambin corn is 2,311 cp so that with a low setback value produces a low retrograde time [2]. One characteristic of local maize is the size of cob and granules which are smaller in size than ordinary corn. This corn is then processed into a mixture of corn rice, boiled, burned and partly as bird food. Madura local maize
has low productivity ranging from 0.9 to 1.0 ton/ha and low selling prices. But the locally dried Madura corn is relatively expensive. So that if crushed and made into a mixture of corn rice has a relatively high selling value [3].

One of the famous corn preparations in the community is corn rice. Corn rice is not a new food for the people of Indonesia, usually, the majority of Indonesian people consume corn as an alternative only the main staple food is still rice. In addition to making corn rice takes a long time and is less practical in cooking. Therefore it is necessary to develop instant corn rice. Instant corn rice is an instant food product that goes through an instantization process so that the cooking process will be faster, easier and practical [4]. With this, making it easier for consumers to cook and more practical without preservatives. To get corn rice with good texture quality and with fast cooking time by the wishes of consumers, so it needs to research optimizing the best manufacturing process of instant Madura corn rice using the Response Surface Methodology (RSM). The RSM method is used because it does not require large amounts of experimental data and does not take a long time [5], [6]. There have been many studies using the RSM method, including on beetroot [5], microorganism level of semi-solid emergency food based [7], rice milk drinks [6], biscuit [8], pumpkin [9], and extraction of nanofibril [10].

2. Methods
This research at the agroindustrial technology laboratory, Trunojoyo University. The materials used in making instant corn rice are local Madura corn. Other materials used besides corn are water and calcium hydroxide water for the cooking process of instant Madura corn rice. The tools used in making instant corn rice are cabinet dryer, 30 mesh sieve, 10 mesh, basin, stove, analytical scales, grinding machine [1]. While the tools used for testing are analytical scales, plates, desiccators, ovens, pans, spatulas, digital thermometers, and stopwatches. This research was conducted on instant Madura corn rice using 2 factors and 5 levels. Calcium hydroxide concentration factor (0%, 0.5%, 1%, 1.5%, 2%) and boiling time factor (20, 30, 40, 50, 60) minutes. The optimization process is carried out with the Central Composite Design (CCD) design with the Response Surface Methodology (RSM) method which results in 13 experimental treatments with 2 repetitions. This research is carried out based on the treatment design that has been made based on Table 1.

| Table 1. Response surface methodology research design |
|------------------------------------------------------|
| Run | Factor Code | Factor Not Code | Calcium hydroxide Concentration (%) | Boiling Time |
|-----|-------------|-----------------|-------------------------------------|--------------|
| 1   | X1 0        | X2 0            | 1                                   | 40           |
| 2   | X1 0        | X2 0            | 1                                   | 40           |
| 3   | X1 1,44121  | X2 0            | 2                                   | 40           |
| 4   | X1 -1,44121 | X2 0            | 2                                   | 40           |
| 5   | X1 1        | X2 -1           | 1.5                                 | 30           |
| 6   | X1 0        | X2 0            | 1                                   | 40           |
| 7   | X1 0        | X2 1,44121      | 1                                   | 60           |
| 8   | X1 -1       | X2 -1           | 0.5                                 | 30           |
| 9   | X1 1        | X2 1            | 1.5                                 | 50           |
| 10  | X1 0        | X2 0            | 1                                   | 40           |
| 11  | X1 -1       | X2 1            | 0.5                                 | 50           |
| 12  | X1 0        | X2 0            | 1                                   | 40           |
3. Results and Discussion

3.1 Water Content
Moisture test was conducted to determine the percentage of water content contained in instant Madura corn rice. To produce the best low water content value, the boiling time of 20-30 minutes with calcium hydroxide concentration is 1.5-2%. Therefore, with the high concentration of calcium hydroxide, the water content of instant Madura corn rice is getting lower. The highest percentage in this test using crosshairs is 3.533% with a boiling time of 43.948 minutes and a calcium hydroxide concentration of 0.947%. The lowest percentage is 1.237% with a boiling time of 20.077 minutes and calcium hydroxide concentration of 1.998%. This is thought to be due to the nature of calcium hydroxide which gives off heat when it reacts with water so that it destroys the corn pericarp faster, which results in the absorption of more water so that the starch gelatinization process is more complete. As a result, more water is released from the starch granules which break when drying so that the amount of water that is evaporated is more and the water content is lower. The addition of calcium hydroxide water for soaking in the tortillas affects the tortilla's moisture content to be lower [11], [12].

3.2 Cooking Time
The results of the cooking time analysis are used to find out how long the cooking time is from the raw ingredients until an indicator of the maturity of the ingredients appears. To produce a shorter cooking time with the best combination, the boiling time of 50-60 minutes with the concentration of calcium hydroxide is 0-0.5%. Therefore with a high boiling time, the time to cook instant Madura corn rice is getting faster, because the longer the boiling of the gelatinization process is more perfect [12]. Causing the amylose molecule to diffuse out of the starch granules marked by the turbidity of the cooking water. The highest percentage in this test using crosshairs is 8.226 minutes with a boiling time of 59.749 minutes and a calcium hydroxide concentration of 1.998%. The lowest percentage is 6.913 minutes with a boiling time of 59.933 minutes and calcium hydroxide concentration of 0.003%.

3.3 Color Fondness
Color fondness test was conducted to determine the percentage of panelist preferences for instant Madura corn rice color. To produce a high color preference value with the best combination, the boiling time of 50-60 minutes with the concentration of calcium hydroxide is 0-0.5%. To produce the best combination of the calcium hydroxide concentration of 0-0.5%. The higher the concentration of calcium hydroxide used, the color will be increasingly dull [13]. Therefore by increasing the boiling time, it increases the color preference for instant Madura corn rice. The highest percentage in this test using crosshairs is 4.550% with a boiling time of 59.841 minutes and a calcium hydroxide concentration of 0.003%. The lowest percentage is 2,323% with a boiling time of 59,933 minutes and calcium hydroxide concentration of 1,998%.

3.4 Aroma Fondness
Aroma fondness test was carried out to determine the percentage of panelists' preference for the aroma of instant Madura corn rice. To produce a high aroma preference value with the best combination, boiling time of 50-60 minutes with calcium hydroxide concentration is 0.5-1%. The more lime concentration is added, the panelists' preference for aroma [14]. The highest percentage in this test using crosshairs is 3.755% with a boiling time of 59.998 minutes and a calcium hydroxide concentration of 0.772%. The lowest percentage is 2.983% with a boiling time of 32.435 minutes and calcium hydroxide concentration of 1.998%.

3.5 Taste Fondness
The taste fondness test was carried out to determine the percentage of panelists' preference for the taste of instant Madura corn rice. To produce a high taste preference value with the best combination, boiling time of 50-60 minutes with the concentration of calcium hydroxide is 0-0.5%. Therefore by increasing the boiling time, it increases the taste of instant Madura corn rice. The use of calcium
hydroxide concentration can affect the texture of instant Madura corn rice so that it will affect the flavor [15]. The highest percentage in this test using crosshairs is 3.863% with a boiling time of 59.998 minutes and a calcium hydroxide concentration of 0.003%. The lowest percentage is 2.493% with a boiling time of 59.906 minutes and a calcium hydroxide concentration of 1.998%.

3.6 Texture Fondness
A texture fondness test was conducted to determine the percentage of panelist preferences on instant Madura corn rice texture. To produce a high value of texture preference with the best combination, boiling time of 50-60 minutes with calcium hydroxide concentration is 1.5-2%. Therefore by increasing the concentration of calcium hydroxide, it increases the texture of instant Madura corn rice texture. The more calcium hydroxide concentration is added and the longer soaking time the texture value decreases so that the corn kernels are more prone to breaking [11]. The highest percentage in this test using crosshairs is 4.037% with a boiling time of 59.933 minutes and a calcium hydroxide concentration of 1.998%. The lowest percentage is 3.132% with a boiling time of 29.605 minutes and a calcium hydroxide concentration of 0.054%.

3.7. Overall Fondness
The overall fondness test was conducted to determine the percentage of panelist preferences for the whole instant Madura corn rice. To produce a high taste preference value with the best combination, boiling time of 20-30 minutes with calcium hydroxide concentration is 1.5-2% or boiling time 50-60 minutes with calcium hydroxide concentration is 0-0.5 %. Therefore by increasing the concentration of calcium hydroxide, it increases the overall preference for instant Madura corn rice. The higher the concentration of nixtamal corn, the higher the level of preference for the panelists to cooked tortilla chips [16]. The highest percentage in this test using crosshairs is 3.913% with a boiling time of 20.086 minutes and a calcium hydroxide concentration of 1.998%. The lowest percentage was 3.249% with a boiling time of 20.002 minutes and a calcium hydroxide concentration of 0.003%.

3.8. Optimization
Instant Madura corn rice has been tested for moisture content, cooking time, and sensory test. Then from the test results, the data were analyzed using Minitab software with the RSM model to find out its optimization. Following are the results of the optimization criteria for instant Madura corn rice in this study:

| Goal   | Target | Limit Lower | Limit Upper | Weight | Importance |
|--------|--------|-------------|-------------|--------|------------|
| Color  | Maximum| 4.550       | 2.323       | 1      | 1          |
| Aroma  | Maximum| 3.755       | 2.983       | 1      | 1          |
| Teste  | Maximum| 3.863       | 2.493       | 1      | 1          |
| Texture| Maximum| 4.037       | 3.132       | 1      | 1          |
| Overall| Maximum| 3.913       | 3.249       | 1      | 1          |

Based on Table 2 it can be seen that the targets for color, aroma, texture, taste and overall are 4.550; 3.755; 3.863; 4.037; 3.913. The target for color, aroma, texture, taste and overall is maximum. The values from the table are then reprocessed to obtain the optimum value, which is contained in the figure 1.
Based on Figure 1 shows the optimal composition of boiling time and calcium hydroxide concentration analyzed using the response optimizer. The best composition of boiling time and calcium hydroxide concentration is 60 minutes and 0%. Another value that can be known is desirability that is equal to 0.9087 which means the value of desirability if it is close to 1, then it is said to be optimal [5], [6], [10]. The optimal composition has the response value \( y^\ast \) as follows:

| Respon          | Value |
|-----------------|-------|
| Color Fondness  | 4.56  |
| Aroma Fondness  | 3.61  |
| Taste Fondness  | 3.86  |
| Texture Fondness| 3.81  |
| Overall Fondness| 3.91  |

Based on Table 3, shows that the optimum value for color fondness, aroma fondness, taste fondness, texture fondness, and overall fondness are 4.56; 3.61; 3.86; 3.81; and 3.91.

4. Conclusion

In Madura corn rice instant boiling time and calcium hydroxide concentration do not influence water content, cooking time, and sensory. But if it is seen from the regression equation the calcium hydroxide stone concentration affects because it is the biggest coefficient. The optimum composition of Madura Instant corn rice based on sensory characteristics is boiling time of 60 minutes and calcium hydroxide concentration of 0% (0 grams) with a desirability value of 0.9087.

References

[1] K. Hidayat, D. F. Asfan, and U. A. Nursiyam, “Designing Instant Corn Rice Using the Product Design Phase of Quality Function Deployment,” in *IOP Conference Series: Earth and Environmental Science*, 2020, vol. 515, no. 1, p. 12068.

[2] M. Mojiono and D. N. Sholehah, “Optimasi Ekstraksi Pati Jagung Madura-3 Berdasarkan...
Lama Perendaman dan Konsentrasi NaOH, “Rekayasa,” vol. 13, no. 2, pp. 118–124, 2020.

[3] T. Sugianti and M. Hayati, “Persepsi Petani Madura dalam Menolak Komoditas Jagung Varietas Baru,” J. Embryo, vol. 13, no. 2, 2009.

[4] K. Hidayat, M. F. F. Mu'tamar, R. A. Firmansyah, and W. Illahi, “Instant Corn Rice Product Development,” J. Tek. Ind., vol. 20, no. 2, pp. 117–127, 2019.

[5] Y. Cui Q, F. Wang, M. X. Pang, and J. H. Qi, “Optimization of nitrite content in beetroot fermented by s taphylococci xylosus using response surface methodology (RSM),” in IOP Conference Series: Earth and Environmental Science, 2018, vol. 199, no. 5, p. 52009.

[6] Q. Lin, H. Zhang, J. Li, D. Zhu, and H. Liu, “Optimization of Process Technique of Rice Milk Drinks via Response Surface Methodology (RSM),” in IOP Conference Series: Earth and Environmental Science, 2019, vol. 371, no. 5, p. 52024.

[7] A. N. Shalihah, R. Andoyo, and E. Wulandari, “Optimization of microorganism level of semi-solid emergency food based on denaturated whey protein concentrate (WPC) with different mineral concentration and sterilization levels,” E&ES, vol. 443, no. 1, p. 12069, 2020.

[8] D. R. E. Pradipta and R. Andoyo, “Optimization formulation of high protein biscuit made from denaturated whey protein concentrate and sweet potato flour supplemented with mineral as emergency food,” E&ES, vol. 443, no. 1, p. 12066, 2020.

[9] S. Y. Tang, J. S. Lee, S. P. Loh, and H. J. Tham, “Application of Artificial Neural Network to Predict Colour Change, Shrinkage and Texture of Osmotically Dehydrated Pumpkin,” in IOP Conf Series: Mat Sci Eng, 2017, vol. 206, p. 12036.

[10] G. Chen, L. Zhang, Z. Wang, C. Chen, H. Guo, and G. Wang, “Optimization of a green process for the extraction of nanofibril from windmill palm fiber using response surface methodology (RSM),” Mater. Res. Express, vol. 6, no. 2, p. 25037, 2018.

[11] R. Salazar, G. Arámbula-Villa, G. Luna-Bárncenas, J. D. Figueroa-Cárdenas, E. Azuara, and P. A. Vazquez-Landaverde, “Effect of added calcium hydroxide during corn nixtamalization on acrylamide content in tortilla chips,” LWT-Food Sci. Technol., vol. 56, no. 1, pp. 87–92, 2014.

[12] C.-J. Brenda, G.-M. Marcela, F.-C. J. de Dios, and M.-S. Eduardo, “Effect of steeping time and calcium hydroxide concentration on the water absorption and pasting profile of corn grits,” J. Food Eng., vol. 122, pp. 72–77, 2014.

[13] M. A. Majcher and H. H. Jeleń, “Acrylamide formation in low-fat potato snacks and its correlation with colour development,” Food Addit. Contam., vol. 24, no. 4, pp. 337–342, 2007.

[14] W. Chanjarujit, P. Hongsprabhas, and S. Chaiser, “Physicochemical properties and flavor retention ability of alkaline calcium hydroxide-mungbean starch films,” Carbohydr. Polym., vol. 198, pp. 473–480, 2018.

[15] C. F. Zuhra, “Karya Ilmiah Flavor (Citarasa),” Dep. Kim. Univ. Sumatera Utara. Sumatera Utara, pp. 1–27, 2006.

[16] A. Febrianto, B. Basito, and C. Anam, “Kajian Karakteristik Fisikokimia dan Sensoris Tortilla Corn Chips dengan Variasi Larutan Alkali pada Proses Nikstamalisasi Jagung,” J. Teknosains Pangan, vol. 3, no. 3, 2014.