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Optimization of Mango Flour Formulation (*Mangifera indica* L.) Arumanis Variety using Response Surface Methodology

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ABSTRACT

Mango (Mangifera indica L) is one of commodities with high food loss rate due to the characteristics of mango, which is easily spoiled and difficult to store. One of the strategies to reduce mango food loss caused by post-harvest handling is the diversification of mango products. Mango flour can be developed to minimize mango food waste and enhance its added value. This study aimed to determine the optimum formulation for making mango flour. The study used Response Surface Methodology (RSM) type Central Composite Design (CCD) to optimize mango flour yield, using three factors: rice flour concentration (X1: 2-5%), maltodextrin concentration (X2: 2-5%), and tapioca flour concentration (X3: 2-5%). The significance of response was carried out using analysis of variance (ANOVA) at the 95% confidence level (p<0.05). The linear model was the model suggested by software. Model analysis showed that rice flour and tapioca flour concentration significantly affected mango flour yield, while maltodextrin did not have a considerable impact. Based on the results of this study, the optimum conditions in making mango flour were found using rice flour concentration of 4.94%, maltodextrin concentration of 2.25%, and tapioca flour concentration of 4.88% to produce mango flour yield of 20.9578%.

1. INTRODUCTION

Mango (*Mangifera indica L*) is one type of tropical fruit that is widely consumed by the community because it has a complete aroma, flavor, and nutritional content of both macronutrients (carbohydrates, protein, fat) and micronutrients (vitamins and minerals). In addition, mangoes also contain various bioactive compounds (phenolics and polyphenols) with specific functional properties such as antioxidants and antibacterials (Maldonado-Celis *et al*., 2019; Sarker *et al*., 2017). Mangoes are a group of fruits that are widely cultivated in the Asian region, including Indonesia (Lawson *et al*., 2019). There are more than 1000 mango varieties in the world, with 69 species growing in the tropics (Solís-Fuentes & Durán-de-Bazúa, 2020). From 2021 to 2023, there are three provinces in Indonesia with the most significant mango production that has increased yearly, specifically West Java, Central Java, and East Java, with total production reaching 75% of the national mango production (BPS, 2024).

The increasing annual production of mangoes poses a challenge for mango farmers due to the fruit's perishable nature and its difficulty to keep (FAO, 2018). This factor makes mango fruit one of the commodities with high food loss during harvesting (Le *et al*., 2022). Research conducted by Tarekegn & Kelem (2022) showed that post-harvest handling of mangoes has the most enormous contribution to food loss (18%) in the mango supply chain in Ethiopia. Post-harvest handling of mangoes includes temporary storage in the field, sorting and grading, packaging, loading and unloading, transportation, and marketing. In addition to these factors, mango age and harvesting methods contribute to increased food loss (Le *et al*., 2022). The high moisture content of mango fruit and its soft texture are factors that cause a high level of difficulty in post-harvest handling of mango (Ampah *et al*., 2022). Therefore, various innovations are needed to handle mango fruit to reduce food loss and increase shelf life. Some processed innovations with mango as the essential ingredient include pulp, mango juice concentrate, ready-to-drink juice, wine, jam, jelly, pickles, smoothies, canned fruit, chips, leathers, and powder (Owino & Ambuko, 2021).

One type of mango product still slightly developed is mango flour. The preparation of mango flour uses fillers to increase the yield of mango flour produced (Ratna *et al*., 2021). Research on making mango powder conducted by Agustini & Gafar (2018) created a high yield of mango powder (36.2 ± 1.86%) by adding sugar with a concentration of 30%. The higher the concentration of fillers, the greater the yield of the resulting product. The research shows that fillers contribute to the yield of the resulting powder. Research by Dewayani *et al*. (2020) found that the type of filler used in the process of making onion flour has a significant effect on yield. Onion flour without fillers only produced a yield of 12%, while onion flour with corn starch fillers produced a yield of 20.9% and tapioca flour of 19.9%. The same thing was also achieved in the study conducted by Sari & Kusnadi (2015) using rice flour mixed with tapioca flour in the preparation of instant shrimp paste produced higher yield (8.74%) compared to tapioca flour mixed with wheat flour (7.72%). Selecting fillers with hydrocolloid characteristics can increase flour yield because hydrocolloids can form a film on the surface (Tonin *et al*., 2018). Hydrocolloids widely used as fillers in flour-making include maltodextrin (Erfianti *et al*., 2022) and tapioca flour (Herawati, 2018).

Response Surface Methodology (RSM) is a statistical method that more efficiently determines the optimum condition of a predetermined factor (Mahallati, 2020). There are two models in RSM: Central Composite Design (CCD) and Box Behnken Design (BBD). The choice of model used is based on the number of factors used. CCD is considered to have more accurate results than BBD (Veza *et al*., 2023). This study aimed to optimize the formulation of mango flour using a combination of maltodextrin, rice flour, and tapioca flour as fillers at various concentrations using Central Composite Design (CCD). The optimum response was obtained based on the yield of mango flour produced. The optimum conditions obtained from the software were validated again through experiments.

2. MATERIALS AND METHODS

2.1. Materials

The materials used in this study were Arumanis mangoes from CV Wulan Jaya in Majalengka Regency, West Java, tapioca flour, rice flour (Rosebrand), maltodextrin, and citric acid. Tools used for mango flour production included a digital balance, baking pan, basin, blender (Philips), small bowl, spatula, grinder, 80 mesh sieve, and food dehydrator.

2.2. Methods

2.2.1. Research Design

Optimization of mango flour formulation in this study used three combinations of fillers: rice flour, maltodextrin, and tapioca flour. Optimization was done using Response Surface Methodology (RSM) with Central Composite Design (CCD). The factors used were rice flour concentration 2-5% (w/b), maltodextrin concentration 2-5% (w/b), and tapioca flour concentration 2-5% (w/b), while the research response was mango flour yield (%). The resulting formula is shown in Table 1. The research design consists of 20 combinations.

2.2.2. Preparation of Mango Flour

Arumanis mangoes were washed using clean water to remove dirt attached to the skin and then peeled. Mangoes separated between the flesh and seeds were blanched for 8 minutes at a temperature of 90-95°C. Furthermore, the mango flesh was blended with 0.1% (v/b) citric acid and 10% (v/b) water to produce mango puree. The resulting puree was added with fillers such as maltodextrin, rice flour, and tapioca flour based on Table 1 formulation. The mixed puree was

Table 1. Factors combination in mango flour preparation

Run	Factor 1 (A) Rice flour concentration	Factor 2 (B) Maltodextrin concentration	Factor 3 (C) Tapioca flour concentration
No	%	%	%
1	3.5	3.5	3.5
2	3.5	0.977311	3.5
3	0.977311	3.5	3.5
4	3.5	6.02269	3.5
5	5	2	5
6	3.5	3.5	3.5
7	6.02269	3.5	3.5
8	3.5	3.5	3.5
9	3.5	3.5	3.5
10	5	5	5
11	2	5	5
12	3.5	3.5	0.977311
13	2	2	2
14	5	2	2
15	2	2	5
16	2	5	2
17	3.5	3.5	3.5
18	3.5	3.5	6.02269
19	3.5	3.5	3.5
20	5	5	2

spread on baking sheet and dried using food dehydrator for 20-30 hours at 60°C. Then, the dried mixture of puree and fillers was pulverized using a grinder and sieved using an 80 mesh sieve.

2.2.3 Determination of mango flour yield

The yield of mango flour produced represents the correlation between the weight of mango flour and the weight of the starting materials (puree, rice flour, maltodextrin, and tapioca flour). Determination of mango flour yield uses the following equation:

$$Y = \frac{W_2}{W_1} x100 \qquad (1)$$

Where Y is the amount of mango flour yield (%), W_1 is the weight of the initial ingredients (puree, rice flour, tapioca flour, and maltodextrin) (g), and W_2 is the weight of mango flour after drying (g).

2.2.4 Data analysis

Data analysis was conducted using analysis of variance (ANOVA) in Design Expert 13 software with CCD research design. The response obtained from 20 treatments were inputted into the software to produce the most optimum treatment prediction output. In response analysis, several criteria must be fulfilled, including the model must be significant ($p < 0.05$), the lack of fit value must be insignificant ($p > 0.05$), the adjusted R^2 and predicted R^2 values have a difference of less than 0.2 and the adequate precision value must be more than 4 (Veza *et al*., 2023). Optimization results with desirability values close to 1 have characteristics that match the optimization target (Nelsen, 2023).

2.2.5 Verification

The optimum conditions obtained during the optimization process through the software were then verified. Mango flour was made at this stage based on the software's optimum conditions. The response analysis results obtained are called actual values, which are then compared with the predicted values from the software. The verification results will show the model's accuracy, as suggested by the software (Said & Amin, 2016).

3. RESULTS AND DISCUSSION

3.1. Response analysis

The factors used in this research were rice flour concentration (%), maltodextrin concentration (%), and tapioca flour concentration (%), in response to mango flour yield (%). The response to the combination of filler concentration in making mango flour using Response Surface Methodology (RSM). Table 2 shows the formulation of 3.5% rice flour concentration, 3.5% maltodextrin concentration, and 3.5% tapioca flour concentration producing an average yield value of 18.68% with six replications. At 5% rice flour concentration, 5% maltodextrin concentration, and 5% tapioca flour concentration, the yield of mango flour was 20.8%. However, at 2% concentration of fillers, the yield of mango flour was only 13.2%. This shows that the higher the concentration of fillers, the greater the flour yield. This finding is in line with research conducted by Kasim *et al.* (2023), which showed that the higher the concentration of maltodextrin and tapioca flour in the preparation of chili powder, the greater the yield of chili powder produced due to the increase in total solids used as fillers.

Table 2. Effect of formulation on mango flour yield

Run	Factor 1 (A) Rice flour concentration	Factor 2 (B) Maltodextrin concentration	Factor 3 (C) Tapioca flour concentration	Response Yield
No	%	%	%	%
1	3.5	3.5	3.5	19
2	3.5	0.977311	3.5	16.67
3	0.977311	3.5	3.5	16.8
4	3.5	6.02269	3.5	15
5	5	2	5	20.5
6	3.5	3.5	3.5	19
7	6.02269	3.5	3.5	20.3
8	3.5	3.5	3.5	18.09
9	3.5	3.5	3.5	18.09
10	5	5	5	20.8
11	2	5	5	18.75
12	3.5	3.5	0.977311	16.8
13	2	2	2	13.2
14	5	2	2	17.4
15	2	2	5	17.4
16	2	5	2	11.9
17	3.5	3.5	3.5	20.81
18	3.5	3.5	6.02269	20.3
19	3.5	3.5	3.5	17.1
20	5	5	2	17.8

3.2. Modelling in predicting response

The model used in the optimization process using Response Surface Methodology showed the relationship between the independent variables or factors used: the concentration of rice flour, tapioca flour, and the concentration of maltodextrin to the resulting response, the yield of mango flour. Based on the results of ANOVA analysis, the suggested model was a linear or first-order model with a p-value of 0.0006 or $p < 0.05$. This indicated that mango flour yield was only influenced by rice flour concentration, tapioca flour concentration, and maltodextrin concentration, not the interaction between them (Hepi *et al.*, 2021).

Table 3. ANOVA of filler concentration on mango flour preparation

Factor	p-value
A-rice flour concentration	0.0019
B-maltodextrin concentration	0.7218
C-tapioca flour concentration	0.0009

The resulting p-value of each factor indicates the factor's influence on the response. Based on Table 3, the rice flour concentration has a p-value of 0.0019. The concentration of tapioca flour, with a p-value of 0.0009, indicates that both variables have a significant effect ($p<0.05$) on the yield of mango flour, while the concentration of maltodextrin with a p-value of 0.7218 has no impact ($p>0.05$) on the yield of mango flour. A larger coefficient indicates the factor with the most significant influence. Based on the coefficient data of each factor in Table 4, the influence given by the concentration of tapioca flour is most dominant compared to the concentration of rice flour and maltodextrin. This can be seen based on the coefficient value of tapioca flour concentration (1.12453), which is greater than the coefficient of rice flour concentration (1.03178) and maltodextrin concentration (0.100491).

Research conducted by Ali *et al*. (2022) showed that tapioca flour as a filler in the preparation of mushroom broth produced a greater yield (13.14%) than maltodextrin (10.36). The higher the concentration of maltodextrin used, the lower the yield achieved due to the reduction of water content in the flour. The decreasing water content occurs due to a decrease in the hygroscopicity of the flour produced (Lee *et al*., 2018). Increasing the concentration of maltodextrin can modify the sugar content in flour that has high hygroscopicity to absorb humidity from adjacent water (Sobulska & Zbicinski, 2021). According to research by Islam *et al*. (2024), the yield and moisture content of jackfruit juice powder decreased with increasing maltodextrin concentration. This can be seen in the coefficient values presented in Table 4, which show that the influence of maltodextrin concentration is inversely proportional to the response of mango flour yield. In contrast, rice flour and tapioca flour concentrations are directly proportional to mango flour yield. When the concentration of maltodextrin is increased, the yield of mango flour gets smaller. The following is the equation for the optimization of mango flour formulation on the response of mango flour yield:

$$Y = 10.59015 + 1.03178X_1 - 0.100491X_2 + 1.12453X_3 \quad (2)$$

where X1: Rice flour concentration (%), X2 : Maltodextrin concentration (%), X3 : Tapioca flour concentration (%).

Table 4. The regression coefficient of each factor

Factor	Coefficient
Intercept	10.59015
X_1-Rice Flour Concentration	1.03178
X_2-Maltodextrin Concentration	-0.100491
X_3-Tapioca Flour Concentration	1.12453

Table 5. Statistical analysis of the selected model

Parameter	Result
Lack of Fit	0.2877
R^2	0.6553
Adjusted R^2	0.5906
Predicted R^2	0.4511
Adeq precision	9.8477
Std. deviation	1.54

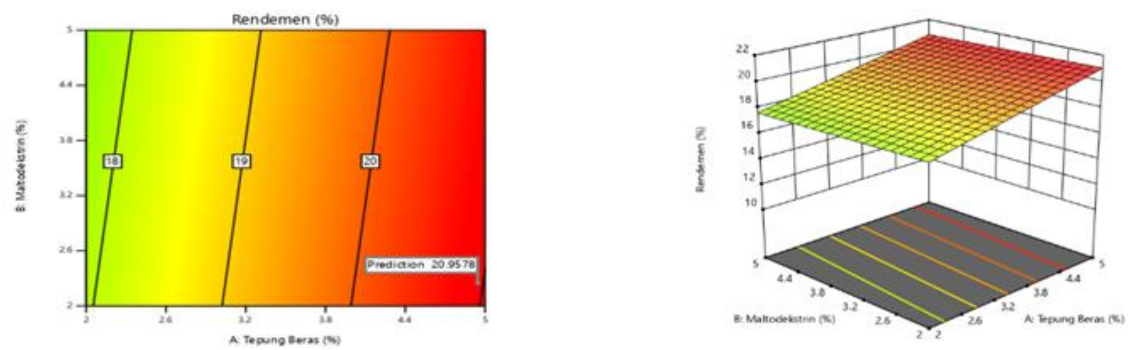
3.3. Model Analysis

R^2 is the coefficient of determination symbol that measures how well predicted data fits the regression line. Based on Table 5, R^2 value of 0.6553 describes that 65% of the data supports the model where the factors affecting mango flour yield are rice flour concentration and tapioca flour concentration. In comparison, the remaining 35% is influenced by other factors not contained in the model. An R^2 value close to 1 indicates that the data presented is getting better because the model can explain the dependent variable's variability well (Sai *et al*., 2023). Alexander *et al*. (2015) pointed out that R^2 value higher than 0.6 is still acceptable, therefore the model still fits the data well. The p-value received from ANOVA analysis using linear model is 0.0006 which shows significant results ($p<0.05$). Therefore, the resulting model can still describe well the variability of the dependent variable. In addition, Table 5 also shows that the parameters of the lack of fit value, the adjusted R^2, predicted R^2 values and the adequate precision value have fulfilled the criteria indicating that the predictions made by the model are acceptable.

The lack of fit test shows an insignificant value; thus, there is a fit of the response data with the model (Nghia *et al*., 2023). The adjusted R^2 coefficient shows the influence of regression factors on the response. The higher the adjusted R^2 value, the greater the factor influence on the reaction. The adjusted R^2 and predicted R^2 values of 0.5906 and 0.4511, respectively, have a difference of less than 0.2, indicating that the adjusted R^2 is good. Adequate precision gives an overview of the accuracy of the recommended model. Based on Table 5, the proper precision value is more than 4, which is 9.8477, so the model can be used (Sai *et al*., 2023).

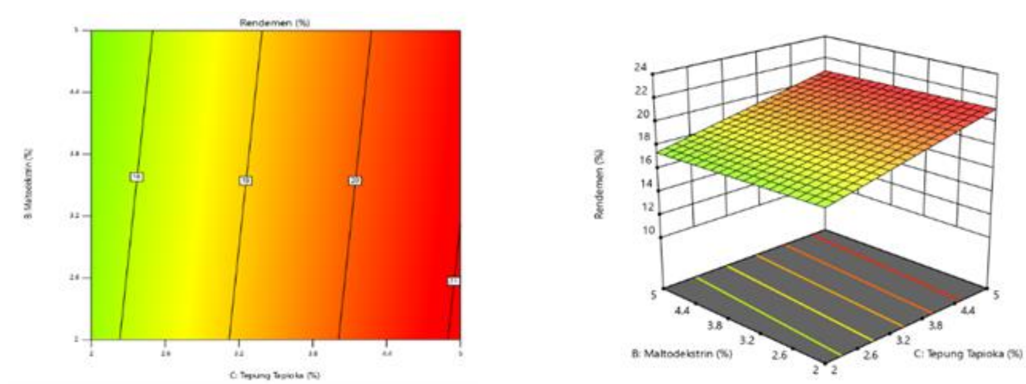
3.4. Influence of factors on response

The interaction between rice flour concentration, maltodextrin concentration, and tapioca flour concentration with mango flour yield is presented as a contour plot and 3-D graph. Figure 1 shows that the yield value of mango flour increases as the concentration of rice flour increases. In contrast, the addition of maltodextrin concentration does not significantly affect the yield of mango flour. The same thing is also seen in Figure 2, which shows that the concentration of maltodextrin does not significantly affect the yield of mango flour. However, the greater the concentration of tapioca flour used, the greater the yield of mango flour. This study is in line with the results of the research conducted by Yulistiani *et al*. (2023), which showed that using maltodextrin as a filler would increase the total solids of coconut milk powder. Still, the resulting addition was also not significantly different. The ability of maltodextrin as a filler can increase the glass transition value and reduce the hygroscopic properties of the product to make the product not easily bind water vapor in the environment (Chuaychan & Benjakul, 2016).



(A) (B)

Figure 1. Contour graph (A) and 3-D graph (B) of response of mango flour yield to rice flour and maltodextrin concentration



(A) (B)

Figure 2. Contour graph (A) and 3-D graph (B) of response of mango flour yield to tapioca flour concentration and maltodextrin concentration

(A) (B)

Figure 3. Contour graph (A) and 3-D graph (B) of response of mango flour yield to tapioca flour concentration and rice flour concentration

In Figure 3, as the concentration of tapioca flour and rice flour increased, the yield of mango flour produced was greater. Rice flour and tapioca flour have a small granule size of 60-100 µm and 35 µm (Burešová *et al*., 2023). Small granules will make the surface area more prominent. This can lead to more excellent water absorption of rice flour. Based on the research of Sari & Kusnadi (2015), the water absorption value of the filler material combination of rice flour and tapioca flour in a ratio of 65:35 was 21.54%, while the combination of wheat flour and tapioca flour in a ratio of 65:35 was 20.30%. Therefore, the more rice flour is used as a filler in making instant shrimp paste, the greater the yield of instant shrimp paste compared to wheat flour.

3.5. Determination of Optimum Formulation of Mango Flour

The optimization stage carried out by the software produces an optimum formulation recommendation. Determination of the optimum point on the factor and response is adjusted to a predetermined target. There are four target/goal categories in RSM: range, target, maximum, and minimum. The optimization criteria for each factor are presented in Table 6. The factors of rice flour concentration, maltodextrin concentration, and tapioca flour concentration were selected for goal in range. This is based on the purpose of this research activity, which is to determine the optimum level of each filler concentration. In the response of mango flour yield, goal maximize was chosen because the optimum point is the formulation that produces the highest yield value.

Furthermore, the criteria determined are processed through software to deliver the optimum combination of formulations, as shown in Table 7. The optimum formulation combination for making mango flour with rice flour concentration of 4.944%, maltodextrin concentration of 2.249%, and tapioca flour concentration of 4.884%. The desirability value obtained is 1, which shows the accuracy of the optimization results (Sai *et al*., 2023). The predicted response of the selected formulation combination is mango flour, with a yield of 20.958%.

Table 6. Optimization criteria

Components	Goal	Lower limit	Upper limit
Rice flour concentration (%)	In range	2	5
Maltodextrin concentration (%)	In range	2	5
Tapioca flour concentration (%)	In range	2	5
Yield (%)	Maximize	11.9	20.81

Table 7. Combination of optimum formulation

Rice flour concentration (%)	Maltodextrin concentration (%)	Tapioca flour concentration (%)	Yield (%)	Desirability
4.944	2.249	4.884	20.958	1.000

3. 6 Verification

Several statistical measures should be considered to achieve a complete view of the Response Surface Methodology (RSM) performance such as R^2, adjusted R^2, and predicted R^2. All these parameters have accomplished the criteria based on the data in Table 5 to validate the accuracy of the model. Therefore, the optimum formulation recommended by the model can be applied for the verification stage to ensure the accuracy of the model in predicting response. The expected value of the software is compared with the actual value of the response, which is the value of the test results using the optimum formulation.

Table 8. Verification results of mango flour formulation optimization

Response	Prediction	95% PI *low*	95% PI *High*	Actual
Yield (%)	20.9578	17.3417	24.5738	20.958

Based on Table 8, the predicted value of the response generated by the software is 20.9578%, while the actual value obtained from the analysis results is 20.958%. The resulting value is still within the 95% prediction interval range, making the empirical model recommended by the system entirely accurate (Hepi *et al*., 2021). Therefore, the optimization formulation of rice flour concentration, maltodextrin concentration, and tapioca flour concentration in making mango flour using Design Expert 13 software is good enough to use. Mango flour is a semi-finished product that can be developed into a variety of products, such as premix flour for cakes, bread and cakes, jelly, puddings, and instant drinks, as well as ice cream and yogurt flavor enhancers. Research conducted by (Akther *et al*., 2020) showed that mango flour could be utilized in making instant mango drinks. The resulting drink received wide acceptance in color, taste, texture, and flavor. In addition, the nutritional profile of instant mango fruit drink was also beneficial for health because it contained low fat and was rich in vitamins and minerals.

4. CONCLUSION

Response Surface Methodology (RSM) produced a linear model (1st order) that showed the relationship between the factors of rice flour concentration, maltodextrin concentration, and tapioca flour concentration to the response, namely, mango flour yield. Model analysis showed that rice flour and tapioca flour concentrations significantly affected mango flour yield, while maltodextrin had no effect. The prediction model produced optimum conditions in the formulation of mango flour: rice flour concentration of 4.94%, maltodextrin concentration of 2.25%, and tapioca flour concentration of 4.88%. These conditions resulted in a mango flour yield response of 20.9578%. The verification results of the optimization process show that the suggested empirical model is quite good because the actual value produced still meets the 95% prediction interval.

REFERENCES

Agustini, S., & Gafar, P.A. (2018). Pengembangan produk bubuk buah mangga (*Mangifera indica L*) instan. *Jurnal Dinamika Penelitian Industri*, ***29***(1), 66. https://doi.org/10.28959/jdpi.v29i1.3617

Akther, S., Alim, M.A., Badsha, M.R., Matin, A., Ahmad, M., & Hoque, S.M.Z. (2020). Formulation and quality evaluation of instant mango drink powder. *Food Research*, ***4***(4), 1287–1296. https://doi.org/10.26656/fr.2017.4(4).077

Alexander, D.L.J., Tropsha, A., & Winkler, D.A. (2015). Beware of R²: simple, unambiguous assessment of the prediction accuracy of QSAR and QSPR models. *Journal of Chemical Information and Modeling*, ***55***(7), 1316–1322. https://doi.org/10.1021/acs.jcim.5b00206

Ali, D.Y., Sunarharum, W.B., & Dyatmika, W.P. (2022). The effect of filler type and concentration on physicochemical properties and organoleptic of mushroom broth powder. *IOP Conference Series: Earth and Environmental Science*, ***1063***, 012003. https://doi.org/10.1088/1755-1315/1063/1/012003

Ampah, J., Dzisi, K.A., Addo, A., & Bart-Plange, A. (2022). Drying kinetics and chemical properties of mango. *International Journal of Food Science*, ***2022***(1). https://doi.org/10.1155/2022/6243228

BPS. (2024). *Produksi Tanaman Buah-buahan, 2021-2023*. Badan Pusat Statistik.

Burešová, I., Lullien-Pellerin, V., Červenka, L., Mlček, J., Šebestíková, R., & Masaříková, L. (2023). The comparison of the effect of flour particle size and content of damaged starch on rice and buckwheat slurry, dough, and bread characteristics. *Foods*, ***12***(13), 2604. https://doi.org/10.3390/foods12132604

Chuaychan, S., & Benjakul, S. (2016). Effect of maltodextrin on characteristics and antioxidative activity of spray-dried powder of gelatin and gelatin hydrolysate from scales of spotted golden goatfish. *Journal of Food Science and Technology*, ***53***(9), 3583–3592. https://doi.org/10.1007/s13197-016-2340-7

Dewayani, W., Samsuri, R., Septianti, E., & Halil, W. (2020). Kajian jenis bahan pengeringan dan beberapa bahan pengisi terhadap kualitas bubuk bawang merah varietas pikatan. *Jurnal Pengkajian Dan Pengembangan Teknologi Pertanian*, ***22***(3), 251. https://doi.org/10.21082/jpptp.v22n3.2019.p251-262

Erfianti, R., Kiranawati, T.M., & Rohajatien, D.U. (2022). Pengaruh maltodekstrin terhadap sifat fisik dan kimia pewarna bunga tapak dara (*Catharanthus roseus*) sebagai biocolor pangan. *Jurnal Agroindustri*, ***13***(1), 1–13. https://doi.org/10.31186/j.agroind.13.1.1-13

FAO. (2018). *Food loss analysis: causes and solutions Case study on the mango value chain in the Republic of India*. Food and Agriculture Organization.

Hepi, D.A., Yulianti, N.L., & Setiyo, Y. (2021). Optimasi suhu pengeringan dan ketebalan irisan pada proses pengeringan jahe merah (*Zingiber Officinale var. rubrum*) dengan response surface methodology (RSM). *Jurnal Beta (Biosistem Dan Teknik Pertanian)*, ***9***(1), 66–75. https://doi.org/10.24843/JBETA.2021.v09.i01.p07

Herawati, H. (2018). Potensi hidrokoloid sebagai bahan tambahan pada produk pangan dan nonpangan bermutu. *Jurnal Penelitian dan Pengembangan Pertanian*, ***37***(1), 17–25. https://doi.org/10.21082/jp3.v37n1.2018.p17-25

Islam, M.Z., Jahan, M.I., Monalisa, K., Rana, R., & Hoque, M.M. (2024). Impact of maltodextrin, egg white protein addition and microwave-assisted foam mat drying on drying kinetics, microstructures, physicochemical and quality attributes of jackfruit juice powder. *LWT*, ***200***, 116158. https://doi.org/10.1016/j.lwt.2024.116158

Kasim, M.M., Une, S., & Limonu, M. (2023). Karakteristik fisik dan kimia bubuk cabai rawit (*Capsicum Frutescens L*) pada berbagai konsentrasi bahan pengisi dengan metode foam mat drying. *Jambura Journal of Food Technology*, ***5***(1), 106–117.

Lawson, T., Lycett, G.W., Ali, A., & Chin, C.F. (2019). Southeast Asian mangoes (*Mangifera indica L*) are characterized according to their physicochemical attributes. *Scientia Horticulturae*, ***243***, 189–196. https://doi.org/10.1016/j.scienta.2018.08.014

Le, T.D., Nguyen, T.V., Muoi, N.V., Toan, H.T., Lan, N.L., & Pham, T.N. (2022). Supply chain management of mango (*Mangifera indica L.*) fruit: A review focusing on product quality during post-harvest. *Frontiers in Sustainable Food Systems*, ***5***. https://doi.org/10.3389/fsufs.2021.799431

Lee, J.K.M., Taip, F.S., & Abdullah, Z. (2018). Effectiveness of additives in spray drying performance: a review. *Food Research*, ***2***(6), 486–499. https://doi.org/10.26656/fr.2017.2(6).134

Mahallati, M.N. (2020). Chapter 9 - Advances in modeling saffron growth and development at different scales. *Saffron Science, Technology and Health Woodhead Publishing Series in Food Science, Technology and Nutrition*, 139-167. https://doi.org/10.1016/B978-0-12-818638-1.00009-5

Maldonado-Celis, M.E., Yahia, E.M., Bedoya, R., Landázuri, P., Loango, N., Aguillón, J., Restrepo, B., & Ospina, J.C.G. (2019). Chemical composition of mango (*Mangifera indica L.*) fruit: Nutritional and phytochemical compounds. *Frontiers in Plant Science*, 10. https://doi.org/10.3389/fpls.2019.01073

Nelsen, T.C. (2023). Chapter seven – Probability. *Probability and Statistics for Cereals and Grains: A Guide to Measurement and Analysis*, 75-79. https://doi.org/10.1016/B978-0-323-91724-7.00014-9

Nghia, N.T., Tuyen, B.T.K., Quynh, N.T., Thuy, N.T.T., Nguyen, T.N., Nguyen, V.D., & Tran, T.K.N. (2023). Response methodology optimization and artificial neural network modeling for the removal of sulfamethoxazole using an ozone–electrocoagulation hybrid process. *Molecules*, ***28***(13), 5119. https://doi.org/10.3390/molecules28135119

Owino, W.O., & Ambuko, J.L. (2021). Mango fruit processing: options for small-scale processors in developing countries. *Agriculture*, ***11***(11), 1105. https://doi.org/10.3390/agriculture11111105

Ratna, N.K.A.N., Puspawati, G.A.K.D., & Permana, I.D.G.M. (2021). Pengaruh konsentrasi maltodekstrin dan tween 80 terhadap karakteristik bubuk minuman instan bunga gumitir (*Tagetes erecta L.*). *Jurnal Ilmu Dan Teknologi Pangan (ITEPA)*, ***10***(4). https://doi.org/10.24843/itepa.2021.v10.i04.p21

Sai, D.A., Nataraj, K.S., & Lakshmana, R.A. (2023). Response surface methodology-a statistical tool for the optimization of responses. *Global Journal of Addiction & Rehabilitation Medicine*, ***7***(1), 555705. https://doi.org/10.19080/GJARM.2023.07.555705

Said, K.A.M., & Amin, M.A. (2016). Overview on the response surface methodology (RSM) in extraction processes. *Journal of Applied Science & Process Engineering,* ***2***(1), 8–16. https://doi.org/10.33736/jaspe.161.2015

Sari, V.R., & Kusnadi, J. (2015). Pembuatan petis instan (kajian jenis dan proporsi bahan pengisi) [In press April 2015]. *Jurnal Pangan Ddan Agroindustri, 3(2), 381–389.*

Sarker, A., Amin, N., Shimu, I.J., Akhter, Md.P., Alam, Md.A., Rahman, Md.M., & Sultana, H. (2017). Antimicrobial activity of methanolic extract of langra mango pulp. *Journal of Pharmacognosy and Phytochemistry*, ***6***(6), 28–30. http://naturalhomeremedies.co/Mango.html

Sobulska, M., & Zbicinski, I. (2021). Advances in spray drying of sugar-rich products. *Drying Technology*, ***39***(12), 1774–1799. https://doi.org/10.1080/07373937.2020.1832513

Solís-Fuentes, J. A., & Durán-de-Bazúa, M.d.C. (2020). Chapter 8 - Mango seed: Mango (*Mangifera indica L.*) seed and its fats. *Nuts and Seeds in Health and Disease Prevention (second Edition)*, 79–90. Elsevier. https://doi.org/10.1016/B978-0-12-818553-7.00008-5

Tarekegn, K., & Kelem, F. (2022). Assessment of Mango Post-Harvest Losses along Value Chain in the Gamo Zone, Southern Ethiopia. *International Journal of Fruit Science*, ***22***(1), 170–182. https://doi.org/10.1080/15538362.2021.2025194

Tonin, I. P., Ferrari, C. C., da Silva, M. G., de Oliveira, K. L., Berto, M. I., da Silva, V. M., & Germer, S. P. M. (2018). Performance of different process additives on the properties of mango powder obtained by drum drying. *Drying Technology*, ***36***(3), 355–365. https://doi.org/10.1080/07373937.2017.1334000

Veza, I., Spraggon, M., Fattah, I. M. R., & Idris, M. (2023). Response surface methodology (RSM) for optimizing engine performance and emissions fueled with biofuel: Review of RSM for sustainability energy transition. *Results in Engineering*, ***18***, 101213. https://doi.org/10.1016/j.rineng.2023.101213

Yulistiani, F., Nuraeni, A., Mardiah, A.A.S., Hidayatulloh, I., Elizabeth, L., & Nurcahyo. (2023). The Effect of Maltodextrin Concentration and Spray Dryer Drying Temperature on the Characteristics of Coconut Milk Powder. *Fluida: Journal of Science and Technology*, ***16***(1), 43–48. https://doi.org/10.35313/fluida.v16i1.4006