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Sensory Evaluation of Jam from Watermelon Waste Using Response Surface Methodology

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Abstract— The present work is focused on the sensory quality of jam produced by watermelon rind. Response surface methodology (RSM) was used to optimize the sensory quality of watermelon jam by the formulation of ingredients such as watermelon rind (400-800g), sugar (400-800g), pectin (10-30g) and citric acid (2-4g). Results showed that the model fit was significant ($p < 0.05$) and there was satisfactory correlation between actual and fitted values. Data obtained from RSM on watermelon rind (WMR) jam production were subjected to the analysis of variance (ANOVA) and analyzed using a second order polynomial equation. The response sensory analysis such as color, taste, aroma and texture was studied during experimental runs of WMR jam processing. The highest sensory score was given by jam production with watermelon rind 585.8568g, sugar 618.1818g, pectin 20.1010g and citric acid 2.7677g. Jam produced under the optimum conditions for sensory score was again subjected to evaluation of sensory values and the results were compared with the RSM predictions.

Keywords— Watermelon Rind (WMR), jam, pectin, sugar, optimization, RSM

1. Introduction

Jam is a prepared fruit cooked to a precise formula so that the natural pectin and acid are extracted and, together with added sugar, forms a colourful and tasteful mixture which sets well and keeps for a long time. According to the specification of the Codex Alimentarius Commission the finished jam should contain more than 65% TSS. Sugar constitutes more than 40% of total weight and 80% of total solids in jam [1]. The amount of added pectin needed to give a good gel also depends on the type of fruit used in the jam. Sugar serves as a preserving agent, contribute flavor, and acids gelling [2]. Watermelons are the popular fruits of the Myanmar and especially grown in Yangon Division and Bago Division. Watermelon (Citrullus lanatus) is a tropical fruitwidely consumed around the world. The fruit is native to Africa and has been cultivated for thousands of years in many Middle East and South East Asia countries [3]. Citrullus lanatus thrive more in the tropical regions and enjoy worldwide popularity for its aesthetic tastes and nutritional compositions [4]. Nutritionally, the fruit contains up to 95% water, poor in vitamin C but contain other essential vitamins and minerals necessary for healthy growth [5]. Pawpaw and watermelon fruits have been reported to be nutritive and high in antimicrobial and antioxidant properties that can scavenge free radicals, thereby improving the antioxidant status of the body [6]. Fruit jams are commonly used with breads, cookies, cake fillings and others [7]. Several fruits and mixed fruits wastes have been reutilized for producing value added product such as jam with acceptable physical, chemical and rheological properties [8]. However, reports of jam made from watermelon rind (WMR) waste is very scarce showing that watermelon wastes from restaurants, food and beverages processing lines are scantly being reused. Chemically WMR contain large amount of water with promising levels of solid matters but devoid of high content of soluble sugar. These characteristics made it a viable candidate for the production of high quality jam. This novel use of WMR will among other things reduce the amount of the waste discarded, create more income for farmers, food processors and more importantly reduce environmental impacts of the waste (Souad, A.M.,et.,al., 2012).

The objective of the present work is to produce jam from waste of watermelon or watermelon ring. The quality of the jam depends on the proportion of the mixture which can be determined by sensory analysis. In product development and optimization, Response Surface Methodology (RSM) is used to model and optimise the response affected by levels of one or more quantitative factors [10]. This method has been successfully applied by several authors to determine the optimum formulation for a food product [11],[12]. The RSM is an innovative approach to model a system with the collection of statistical techniques where in interactions between multiple processes variables can be identified with a fewer experimental trials [13]. The RSM experimental design is an efficient approach to deal with a large number of variables and there are several reports on application of RSM for the evaluation of sensory analysis [14].

2. Materials and Methods

2.1 Materials

In this research work, fresh watermelon wastes (rind only) were collected from local juice processing restaurants located at Hlaing Township, Yangon, Myanmar. The rings are collected between 9 am and 10 am in order to maintain their natural content before being stored immediately after collection at 4ºC to avoid any chemical deterioration before processing day. Food additives such as sugar, salt, citric acid, pectin and commercial grade preservatives (potassium sorbate and sodium benzoate) were purchased from local markets.

2.2 Preparation of Watermelon Ring Jam

Good and sound watermelon rings were thoroughly washed with water. The washed watermelon rings were then cored, sliced and placed in a juice extractor to obtain juice. The extracted juice was placed in the stainless steel pan mixed with sugar and pectin then heated under controlled temperature at 90°C and stirred thoroughly until soluble solid content of jam was obtained 65°Brix. And then, citric acid, salt and potassium sorbate were added and thoroughly agitated. Finally, the firm watermelon ring jam was carefully poured into the sterilized glass bottle and sealed with sterilized cap and then storage at room temperature.

2.3 Optimization of Watermelon Ring Jam Preparation for Sensory Analysis

The Response Surface Methodology (RSM) contains of a group of empirical techniques used for the evaluation of relationship between clusters of controlled experimental factors and measured responses. The RSM was employed to optimize the process ingredients like WMR juice, sugar, pectin and citric acid in the WMR jam preparation. The ranges of these four ingredients are given in Table 1. The statistical software package “Minitab 18**”** was used to analyze the experimental data. All variables were taken at a central coded value of zero and the minimum and maximum ranges of variables investigated are displayed in (Table 1). Experiments were performed according to the Central Composite Design (CCD) in the RSM. The design of experiment was given in Table 2. Upon the completion of experiments, the average maximum sensory evaluation of WMR jam for color, taste, aroma and texture was taken as the response (Y). A multiple regression analysis of the data was carried out for obtaining an empirical model that relates the response measured to the independent variables. A second-order polynomial equation is (4) where, $Y = \beta_0 + \sum_{i=1}^{k} \beta_i X_i + \sum_{i=1}^{k} \beta_{ii} {X_i}^2 + \sum_{n=1}^{\infty} \quad \sum_{i=1}^{k=1} \beta_i X_i$

Y = (1) Where Y is the measured response, $\beta 0$ is the intercept term, βi are linear coefficients, βii are quadratic coefficient, $\beta i\, j$ is interaction coefficient, and Xi and Xj are coded independent variables. The optimal concentrations of the critical variables were obtained by analyzing response surface methodology. The statistical analysis of the model was represented in the form of analysis of variance (ANOVA).

Table 1. Coded and Actual Levels of Ingredients for Design of Experiment

Ingredients	Code	Code Levels				
		-2	-1	0	1	2
Watermelon Rind	A	400	500	600	700	800
Sugar	B	400	500	600	700	800
Pectin	C	10	15	20	25	30
Citric Acid	D	2	2.5	3	3.5	4

Table 2. Experimental Design Matrix for Preparation of Watermelon Waste Ring Jam

Run	**Watermelon rind**	**Sugar**	**Pectin**	**Citric acid**
1	0	0	0	-2
2	1	-1	-1	-1
3	2	0	0	0
4	1	1	-1	-1
5	0	0	0	2
6	-2	0	0	0
7	1	1	1	1
8	-1	1	1	1
9	0	0	0	0
10	0	0	2	0
11	-1	1	1	-1
12	-1	1	-1	1
13	-1	-1	-1	1
14	0	-2	0	0
15	0	0	0	0
16	0	0	0	0
17	-1	-1	1	-1
18	1	1	1	-1
19	1	-1	1	-1
20	0	0	-2	0
21	0	2	0	0
22	-1	-1	1	1
23	1	1	-1	1
24	0	0	0	0
25	0	0	0	0
26	0	0	0	0
27	0	0	0	0
28	1	-1	-1	1
29	-1	1	-1	-1
30	1	-1	1	1
31	-1	-1	-1	-1

2.4 Sensory Evaluation

The sensory evaluation was carried out by an untrained panel of 40 members (20 males and 20 females) in the age 20 – 50 years consisting of faculty and graduate students of the Department of Industrial Chemistry, University of Yangon. The sensory evaluation was carried out for the WMR jam samples for the factors colour, taste, aroma and texture. Overall acceptability of WMR jam samples were evaluated following nine-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much, 1 = dislike extremely).

3. Results and Discussion

3.3 Optimization of Watermelon Rind Jams Production for Sensory Analysis

The results obtained were given in Table 3. For sensory analysis of foods of WMR jam, a polynomial model was proposed. The four responses, namely color, taste, aroma and texture of the prepared WMR jams were given as polynomials in equations (2), (3), (4) and (5) respectively.

Table (3) Central Composite Design (CCD) of Factors in Coded Levels with Sensory Analysis of Watermelon Rind

Run	Colour		Taste		Aroma		Texture	
	Experimental	Predicted	Experimental	Predicted	Experimental	Predicted	Experimental	Predicted
1	7.35	7.51	7.34	7.44	7.40	7.60	7.50	7.44
2	5.90	6.21	5.40	6.27	6.10	6.32	5.90	6.06
3	7.38	5.45	7.28	5.25	7.15	5.94	7.38	5.62
4	7.30	7.48	7.30	7.59	7.90	7.63	7.30	7.52
5	5.80	5.60	5.35	5.22	5.90	5.44	5.85	5.65
6	7.85	6.68	7.84	6.37	7.50	6.45	7.85	6.55
7	6.30	7.29	6.20	7.37	6.30	7.59	6.40	7.65
8	6.00	6.37	6.10	6.36	6.50	5.98	6.20	6.25
9	7.80	8.88	7.70	8.84	7.90	8.86	7.60	8.83
10	7.40	6.86	7.40	7.07	7.20	7.06	7.40	6.95
11	8.89	7.07	8.84	7.19	8.90	7.24	8.90	7.30
12	5.90	6.17	5.89	5.18	6.50	5.11	5.90	5.64
13	7.01	7.14	6.40	6.45	6.50	6.47	7.20	6.96
14	8.83	7.47	8.80	7.54	9.00	7.17	8.82	7.73
15	6.95	8.88	6.94	8.84	7.10	8.86	6.95	8.83
16	8.85	8.88	8.70	8.84	8.70	8.86	8.60	8.83
17	7.80	7.55	7.70	7.89	7.90	7.99	7.60	7.49
18	7.85	7.99	7.84	7.64	7.50	7.78	7.85	8.01
19	5.90	6.25	5.89	5.76	6.50	5.86	5.90	5.98
20	6.60	6.63	6.50	6.40	6.60	6.64	6.56	6.42
21	8.30	8.26	8.27	8.15	7.90	7.73	8.81	8.44
22	6.90	6.86	7.50	7.07	6.70	6.73	6.90	7.00
23	6.00	6.27	6.10	6.19	6.50	6.72	6.20	6.22
24	8.90	8.88	8.91	8.83	9.00	8.85	8.80	8.83
25	8.87	8.88	8.83	8.84	8.80	8.86	8.91	8.83
26	8.94	8.88	8.91	8.84	8.90	8.85	8.93	8.83
27	8.88	8.88	8.87	8.83	8.70	8.85	8.87	8.83
28	4.90	4.99	4.87	4.87	5.10	5.42	4.90	5.32
29	7.40	7.39	7.40	7.15	7.20	7.08	7.40	7.63
30	5.50	5.55	5.40	5.49	5.30	5.67	6.50	6.18
31	8.55	8.35	8.54	8.41	8.87	8.45	8.53	8.39

Colour = 8.8800 - 0.3050 A + 0.1958 B + 0.0583 C - 0.4767D - 0.7029 A^2 -0.2529 B^2 - 0.5342C^2 - 0.5804 D^2 + 0.5575 AB + 0.2075 AC+ 0.1187 BC + 0.1300 CD ------------(2)

Taste = 8.8371 - 0.2804 A + 0.1529 B + 0.1662 C - 0.5562 D - 0.7556 A^2-0.2469 B^2 - 0.5256C^2 - 0.6269 D^2 + 0.6456 AB + 0.1419 AC+ 0.1406 BC + 0.2844 CD ----------(3)

Aroma = 8.857 - 0.1279 A + 0.1388 B + 0.1054 C - 0.5404 D - 0.6646 A^2-0.3521 B^2 - 0.5021 C^2 - 0.5833 D^2 + 0.6669 AB + 0.2669 AC+ 0.1544 BC + 0.1794 CD ---------(4)

Texture = 8.8329 - 0.2325 A + 0.1767 B + 0.1333 C - 0.4475 D - 0.6876 A^2-0.1863 B^2 - 0.5363C^2 - 0.5713 D^2 + 0.5550 AB + 0.2050 AC+ 0.1737 AD + 0.1425 BC - 0.1388 BD + 0.2362 CD ---------(5)

The ANOVA tables is given in Table 4 to 7 for color, taste, aroma and texture respectively. The F value of 118.04 for color, 174.82 for taste, 60.82 for aroma and 92.62 for texture implies the model is significant. The value of "prob > F "greater than 0.1 indicate that the model term is not significant and "prob > F "values less than 0.05 indicate that model term is significant. The coefficients of determination (R^2) for sensory values were found to be 97.61% for color, 98.46% for taste, 95.77% for aroma and 97.34% for texture. The predicted R^2 value 89.65% for color, 94.14% for taste, 83.25% for aroma and 85.46% for texture is in reasonable agreement with the adjusted R^2 value of 96.01% for color, 97.43% for taste, 92.94% for aroma and 95.00% for texture.

Table (4) Analysis of Variance (ANOVA) for the Optimization of Sensory Analysis of Watermelon Rind Jam for Colour

Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Model	12	41.5522	3.4627	61.22	0.000
Linear	4	8.6877	2.1719	38.40	0.000
Square	4	26.7066	6.6766	118.04	0.000
2-Way Interaction	4	6.1578	1.5395	27.22	0.000
Error	18	1.0181	0.0566		
Lack-of-Fit	12	1.0105	0.0842	66.48	0.000
Pure Error	6	0.0076	0.0013		
Total	30	42.5702			
R-Squared		97.61%			
Adjusted R-Squared		96.01%			
Predicted R- Squared		89.65%			

Table (5) Analysis of Variance (ANOVA) for the Optimization of Sensory Analysis of Watermelon Rind Jam for Taste

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	12	48.7936	4.0661	95.88	0.000
Linear	4	10.5377	2.6344	62.12	0.000
Square	4	29.6543	7.4136	174.82	0.000
2-Way Interaction	4	8.6017	2.1504	50.71	0.000
Error	18	0.7633	0.0424		
Lack-of-Fit	12	0.7314	0.0609	11.45	0.004
Pure Error	6	0.0319	0.0053		
Total	30	49.5569			
R-Squared		98.46%			
Adjusted R-Squared		97.43%			
Predicted R- Squared		94.14%			

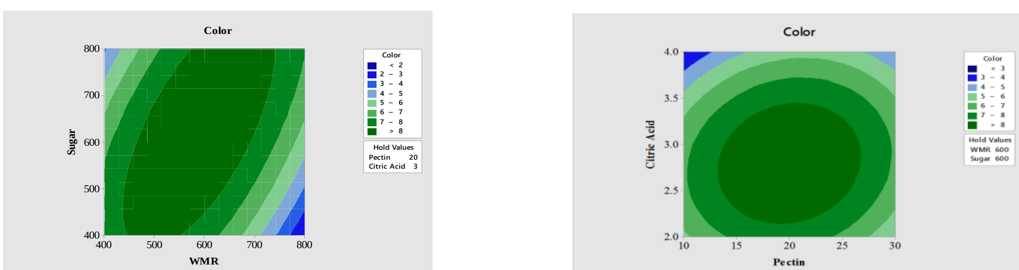
Table (6) Analysis of Variance (ANOVA) for the Optimization of Sensory Analysis of Watermelon Rind Jam for Aroma

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	12	42.9360	3.5780	33.93	0.000
Linear	4	8.1306	2.0327	19.28	0.000
Square	4	25.6541	6.4135	60.82	0.000
2-Way Interaction	4	9.1512	2.2878	21.70	0.000
Error	18	1.8981	0.1055		
Lack-of-Fit	12	1.8010	0.1501	9.27	0.006
Pure Error	6	0.0971	0.0162		
Total	30	44.8341			
R-Squared		95.77%			
Adjusted R-Squared		92.94%			
Predicted R- Squared		83.25%			

Table (7) Analysis of Variance (ANOVA) for the Optimization of Sensory Analysis of Watermelon Rind Jam for Texture

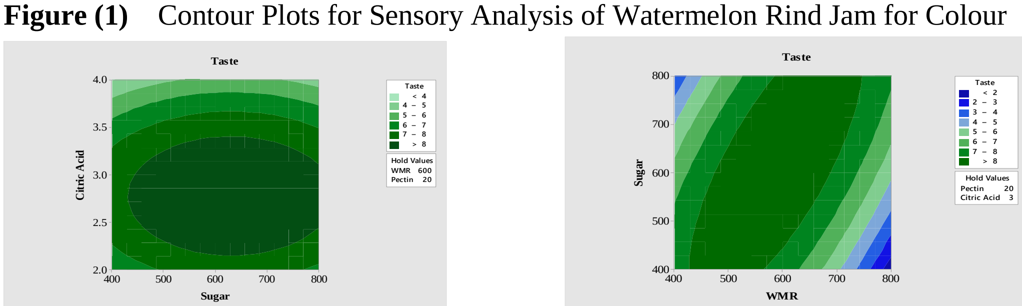
Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	14	40.6463	2.9033	41.76	0.000
Linear	4	7.2792	1.8198	26.17	0.000
Square	4	25.7573	6.4393	92.61	0.000
2-Way Interaction	6	7.6098	1.2683	18.24	0.000
Error	16	1.1125	0.0695		
Lack-of-Fit	10	1.0357	0.1036	8.10	0.009
Pure Error	6	0.0767	0.0128		
Total	30	41.7587			
R-Squared		97.34%			
Adjusted R-Squared		95.00%			
Predicted R- Squared		85.46%			

The above model can be used to predict the sensory analysis of watermelon rind jam production within the limits of the experimental factors. Figure 1 (a), shows the significant interaction between WMR and sugar, for color. The sensory value of color increases with increase in the amount of watermelon rind and sugar to about 605.469g and 647.052 g respectively and thereafter sensory score decreases with further increase in watermelon rind and sugar. The same trend was observed in second plot which shows an increase in pectin and citric acid resulted increase in sensory value of color up to 20.2852g and 2.8387g respectively. From Figure 2 (a) and (b), the sensory value of taste increases with increase in watermelon rind, sugar, pectin and citric acid to about 611.736g, 642.727g, 21.5108g and 2.788 g respectively and thereafter sensory value of taste decreases with further increase in these four variables. From Figure 3 (a) and (b), the sensory value of aroma increases with increase in watermelon rind , sugar, pectin and citric acid to about 626.177g , 652.369g, 22.3752g and 2.7894 g respectively and thereafter sensory score decreases with further increase in these four variables. The sensory value of color increases with increase in watermelon rind and sugar to about 604.662g and 670.142 g respectively and thereafter sensory score decreases with further increase in watermelon rind and sugar. From Figure 4(a) and (b), the sensory value of texture increases with increase in pectin and citric acid to about 20.2237g and 2.80348 g respectively and thereafter sensory score decreases with further increase in pectin and citric acid. Response surface methodology (RSM) can be used to model and optimized any response affected by levels of one or more quantitative factors. The optimum conditions for the best sensory score of the four outputs were obtained using Response optimizer in Minitab 18. They are: WMR – 585.859g, sugar- 618.182 g, pectin- 20.1010 g and citric acid- 2.7677g. An experimental run was conducted by taking the operating parameters that yielded best sensory value. The jam produced was tested with the panelists and the scores were compared with the predicted value. The overall scores were 8.98 for color, 9.00 for taste, 9.00 for aroma and 8.95 for texture.



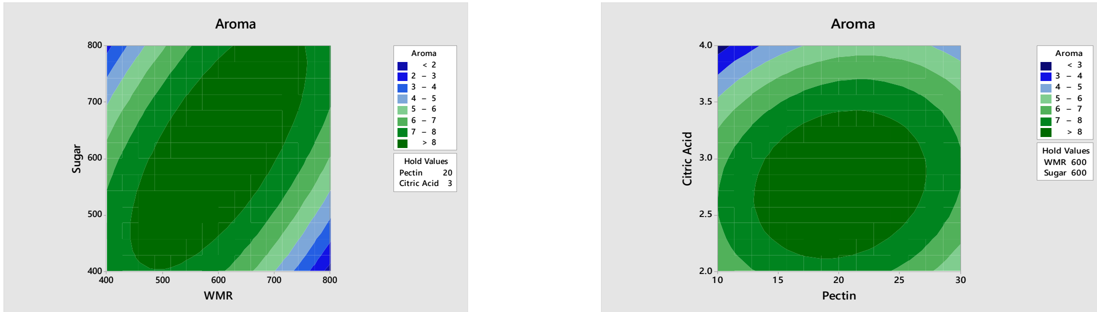
(a) **(b)**

Figure (1) Contour Plots for Sensory Analysis of Watermelon Rind Jam for Colour



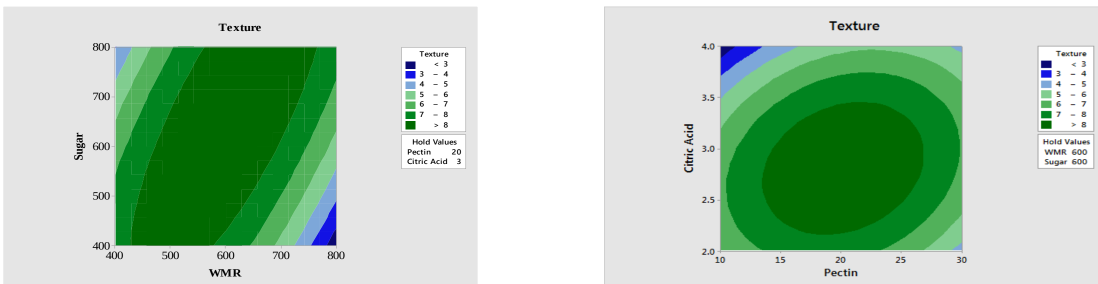
(a) **(b)**

Figure (2) Contour Plots for Sensory Analysis of Watermelon Rind Jam for Taste



(a) (b)

Figure (3) Contour Plots for Sensory Analysis of Watermelon Rind Jam for Aroma



(a) (b)

Figure (4) Contour Plots for Sensory Analysis of Watermelon Rind Jam for Texture

Table (8) Criteria for Numerical Optimization of Process Parameters

Response	Goal	Lower	Target	Weight	Importance	Desirability
Texture	Maximum	4.90	8.93	1	1	1
Aroma	Maximum	5.10	9.00	1	1	
Taste	Maximum	4.87	8.91	1	1	
Color	Maximum	4.90	8.94	1	1	

Table (9) Process Optimum Conditions for Watermelon Rind Jam

PV = Predicted Value, EV= Experimental Value

No.	Ingredients	Value (g)	Colour		Taste		Aroma		Texture	
			PV	EV	PV	EV	PV	EV	PV	EV
1.	Watermelon rind	585.859	8.97	8.98 ±0.2	8.99	9.00 ±0.4	9.00	9.00 ±0. 3	8.97	8.95 ±0.2
2.	Sugar	618.182								
3.	Pectin	20.1010								
4.	Citric acid	2.7677								

4. CONCLUSIONS

The present investigation deals with the production of WMR jam using WMR, sugar, pectin and citric acid. Response Surface Methodology design was used to test the relative importance of sensory outputs the optimum condition for the best sensory score is WMR – 585.859g, sugar- 618.182 g, pectin- 20.1010 g and citric acid- 2.7677g. The experiment run for the optimum conditions obtained from RSM gave a sensory score of 8.98 for color, 9.00 for taste, 9.00 for aroma and 8.95 for texture. The prepared WMR jam had long shelf life and stability at ambient temperature for over six months' storage. The jam preparation with its important acceptable characteristics is capable of being commercialized for industrial use.

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