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OPTIMIZATION OF PROCESS PARAMETERS FOR THE PRODUCTION OF VEGETABLE CHUTNEY POWDER FOR ITS MAXIMUM NUTRIENT CONTENT

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Abstract: Vegetable chutney powder is a ready to cook product which is prepared using different ingredients. Vegetable chutney puree was dried using tray drier at different temperature and with different puree thickness. Response Surface Methodology is used to determine the effect of temperature and thickness on the quality characteristics of vegetable chutney powder. Totally 13 combinations of experimental trials were performed to understand the effect of processing parameters on different effects of vegetable chutney powder. Analysis of variance was performed for all the dependent variables such as temperature and thickness and the predicted R^2 value of protein and carbohydrate were 0.9821 and 0.9634 respectively. The final optimized temperature and thickness for the vegetable chutney powder was found to be 40°C and 3mm respectively. The color value (A-value) and moisture content of vegetable chutney powder was analyzed statistically using *SPSS* 20 and found both the values were significantly influenced by drying temperature.

Key words*: response surface methodology, optimization, central composite design, vegetable chutney powder*

INTRODUCTION

Urban lifestyle, increased prevalence of nuclear family, rising disposable income, improving shelf life of the processed food and reduced cooking time are the major reason for population opting for ready to cook products [1]. Chutneys, pickles and chutney powders are consumed along with rice, breakfast items as a side dish, which

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also increase appetite are considered to be traditional food [2]. Earlier studies in this field includes instant curry leaf chutney powder [3], tamarind leaf chutney powder [4], raw mango chutney powder [5], raw tamarind chutney powder [2] and amla chutney powder [6] are the earlier studies.

Vegetable chutney powder prepared using mixed vegetable such as carrot, beans, capsicum, tomato along with spices was considered to be nutrient rich product as it has all nutrient such as vitamin A, vitamin C, vitamin K, biotin, Manganese derived from mixed vegetable. Extensive reviews conducted in this topic revealed that there was no earlier work in mixed vegetable chutney powder.

Drying process is defined as simultaneous process of heat and mass transfer between the product to the drying air that consists on excess moisture content removal from the product by means of evaporation process, generally caused by heated air convection forces with the objective to maintain the product quality during the storage [7]. Tray dryer is widely used in agricultural drying because of its simple design and capability to dry products at high volume. A tray dryer consists of several stacks of trays placed in an insulated chamber in which hot air is distributed by a fan or natural flow. The air temperature is usually controlled by a thermostat which is normally set between 50°C and 70°C [8].

Response Surface Methodology (*RSM*) is a collection of statistical and mathematical techniques useful for developing, improving and optimization of the process. Statistical software Stat-Ease was used for numerical and graphical optimization of experimental data [9]. The main advantage of *RSM* is to evaluate multiple parameters and their interactions [10]. Optimization theory consist of a body of numerical methods for finding and identifying the best candidate from a collection of alternatives without having to explicitly evaluate all possible alternatives [11]. Once an appropriate approximating model is obtained, this model can then be analyzed using various optimization technique to determine the optimum conditions for the process [12].

The present study was formulated with an objective of optimizing the drying process parameters for making vegetable chutney powder with acceptable sensory and nutritional quality using *RSM* approach.

MATERIALS AND METHODS

Collection of raw materials. The particular variety of vegetables needed for preparing vegetable chutney powder were purchased fresh from the local market on the day of processing in order to ensure that there is no nutrient loss due to storage of vegetables. The other ingredients such as garlic, ginger, sesame seeds, oil, cumin seeds, mustard, red chilies, salt and tamarind were also purchased from the local market in bulk qualities and used throughout the study to reduce the error due to varietal influence.

Preparation of vegetable chutney powder. Various vegetables and other ingredient used for the preparation of chutney powder such as carrot, brinjal, green beans, capsicum, tomato, onion, ginger, garlic, oil, cumin seeds, red chilies, sesame seeds, salt and tamarind were added with sufficient amount of water to get mixed vegetable puree. Chutney puree was prepared by two different methods namely frying method and boiling method. In frying method all ingredients were fried in oil using medium flame whereas in boiling method, pressure cooking of all ingredients without oil in medium flame for

10 minutes. Sensory analysis was used to select the method which yielded good quality mixed vegetable puree. Using the selected method, puree was then dried in a tray drier for a definite temperature (40°C, 50°C, 60°C) and thickness (1mm, 2mm, 3mm). The experimental designs for these drying parameters were obtained using Central Composite Rotatable Design (*CCRD*) obtained from *RSM* (Tab. 1). All the samples were dried till a concordant weight was reached to calculate the drying time.

Quality evaluation of vegetable chutney powder. Prepared vegetable chutney powder was analyzed for its moisture content, color value (A-value), protein and carbohydrate using standard method. Moisture content was analyzed using hot air oven method [13]. The color value (A-value) of the chutney powder was measured using the Hunter LAB Colorimeter [14]. While the Carbohydrate was determined by Anthrone reagent method [15] and the protein content was estimated using Kjeldahl method [16]. The effect of processing temperature and thickness on the nutritional content, moisture and color value (A-value) of prepared chutney was studied. The moisture content and color value (A-value) of the experimental trials were analyzed by *ANOVA* using Statistical Package for Social Scientists (*SPSS*) software, version 20.0 to evaluate the difference at $p<0.05$. The data were analyzed to get mean value with standard deviation (Tab. 4).

Model development and experimental data analysis. Totally 13 trials were performed and the responses such as protein and carbohydrate were obtained (Tab.1). The response value were fit into the quadratic model and ANOVA was performed to understand the effect of process parameter on the responses. The retrieved model were fitted with different process order like linear, interactive and quadratic to get sequential model sum of squares and model summary for validating the model and confirming the goodness of fit of the model.

Table 1. Effect of process parameters on protein, carbohydrate, moisture content and A-value of prepared vegetable chutney powder

Run	*Temperature (°C)*	*Thickness (mm)*	*Protein (mg)*	*Carbohydrate (mg)*	*Moisture content (%)*	*Colour value (A-value)*
1	50.00	1.00	0.53	2.9	4.4	12.31
2	40.00	3.00	0.88	5.5	6.4	9.12
3	50.00	2.00	0.65	3.5	4.7	12.96
4	40.00	1.00	0.66	4.7	5.8	9.07
5	60.00	3.00	0.65	3.7	4.4	14.09
6	50.00	2.00	0.65	3.2	4.6	12.96
7	50.00	2.00	0.61	3.2	4.5	13.18
8	50.00	3.00	0.77	4.4	4.7	12.97
9	50.00	2.00	0.61	3.5	4.6	12.96
10	60.00	2.00	0.56	2.7	4.4	13.72
11	60.00	1.00	0.52	2.2	4.2	13.03
12	50.00	2.00	0.65	3.5	4.6	13.18
13	40.00	2.00	0.80	5.0	6.2	9.32

Model validation. The developed model was evaluated by its R^2 value and Lack of Fit test. Set of experimental trials were performed based on the optimized process conditions and used for the model validation. The experimental and predicted values of process temperature and thickness were also used for the validation of the model. The R^2 values were computed to check the suitability of analysis and closure the R^2 value to unity indicates the goodness of fit of the model.

Optimization. Numerical and graphical optimization was carried out to get the optimum process conditions to retain maximum protein and carbohydrate content in the chutney powder.

RESULTS AND DISCUSSION

Regression analysis for the responses with selected model. Generally the model that fits into the design may produce misleading results which indicates that the validation of the analyzed model is necessary. From Tab. 2 it is clear that the quadratic model gives the maximum R^2 and lesser *p*-value. Further the "Adjusted R^2" and "Predicted R^2" of the quadratic model were found to be maximum ensuring the validation of model (Eq.1). Tab. 2 displays the ANOVA and the regression coefficient of all the model with their coefficients of determination. The statistical tool implies that the proposed model is good for the responses like protein and carbohydrate value possessing no significant lack of fit. The R^2 value of protein and carbohydrate was 0.9821, 0.9634 respectively which indicates satisfactory R^2 value for all the responses since the values are closer to unity [17]. The lesser the value of R^2 denotes the existence of less relevant dependent variables.

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_{12}X_1X_2 + b_{13}X_1X_3 + b_{23}X_2X_3 + b_{11}X_{12} + b_{22}X_{22} + b_{33}X_{32} \quad (1)$$

Table 2. Model adequacy

Source	*Std.dev*	R^2	*Adjusted* R^2	*Predicted* R^2	*Remarks*
Model Summary Statistics					
Protein Value					
Linear	*0.031*	*0.9275*	*0.9130*	*0.8757*	*Suggested*
2FI	*0.029*	*0.9429*	*0.9238*	*0.8645*	*Suggested*
Quadratic	*0.018*	*0.9821*	*0.9693*	*0.9533*	*Suggested*
Carbohydrate value					
Linear	*0.037*	*0.8760*	*0.8512*	*0.7826*	*Suggested*
2FI	*0.037*	*0.8872*	*0.8496*	*0.6486*	*Suggested*
Quadratic	*0.024*	*0.9634*	*0.9372*	*0.7943*	*Suggested*

Effect of process parameter on protein content. The model obtained for predicting the protein value are highly significant at 0.1% level which is presented in Tab. 3. The effect of process parameter on the protein content of the vegetable chutney powder is given in Fig.1A. The protein value significantly decreased during the increase in temperature because the higher the process temperature the more is the denaturation of protein molecules present in the sample [18]. Interactive effect between temperature and thickness exhibited negative impact on the protein content of vegetable chutney powder.

By neglecting the non significant terms in Eq.1 with the coded values of independent variables, Eq.2 describes the effect of processing on the protein value.

$$Protein = +0.63-0.089X_1+0.086X_2-0.022\,X_1\,X_2+0.026\,X_1^2\;(R^2=0.9821) \qquad (2)$$

Effect of process parameter on carbohydrate content. From the model variance analysis, the quadratic model is best suited for predicting the carbohydrate content ($p<0.05$) [19]. From the ANOVA it is clear that the drying temperature and the thickness of vegetable puree significantly affects the carbohydrate content of the prepared product. As the temperature of the process increases the carbohydrate content of the vegetable chutney decreases markedly and also there is gradual increase in the carbohydrate content with the increase in puree thickness during the drying process (Fig.1B). By neglecting the non significant terms in Eq.1 and with the coded values of independent variables, the following Equation (Eq.3) describes the effect of significant process variables on carbohydrate content of vegetable chutney powder.

$$Carbohydrate = +0.34-0.094\,X_1+0.055\,X_2+0.030\,X_1^2\;(R^2=0.9634) \qquad (3)$$

Table 3. ANOVA of the quadratic model for the variables

Variable	Protein value		Carbohydrate value	
	Coefficient of estimate	p value	Coefficient of estimate	p value
Model		<0.0001[a]		<0.0001 [a]
X_1	-0.089	<0.0001[a]	-0.94	<0.0001 [a]
X_2	0.086	<0.0001[a]	+0.55	<0.0001 [a]
$X_1 X_2$	-0.022	0.0442[c]	+0.18	0.1867
X_1^2	+0.026	0.0072[b]	+0.30	0.0123[c]
X_2^2	+0.011	0.1543	+0.20	0.0595
Lack of fit		0.8197[d]		0.1235[d]
Suggested	quadratic	quadratic	quadratic	Quadratic
Model	significant	significant	significant	Significant
R^2	0.9821		0.9634	

[a] - Significant at 0.001 level; [b] - Significant at 0.01 level;
[c] - Significant at 0.05 level; [d] - Not significant.

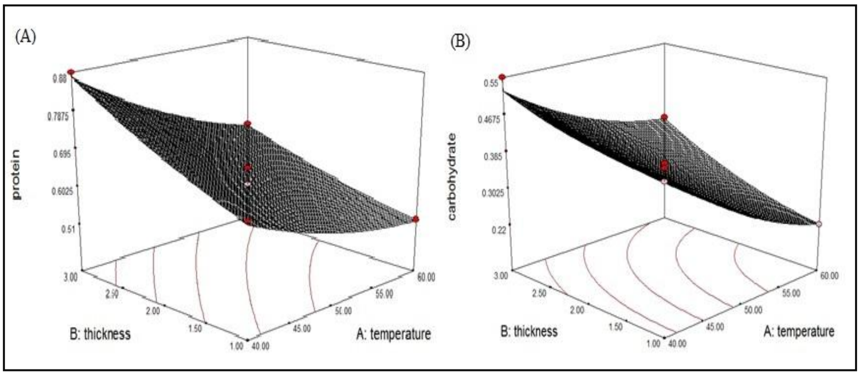

Figure 1. (A) 3D response model of protein with respect to temperature and thickness, (B) 3D response model of carbohydrate with respect to temperature and thickness

Effect of process parameter on moisture content and color value (A-value). Moisture content and color value (A-value) was analyzed for all 13 combinations of trials. From the *ANOVA*, p value for moisture content and colour value (A-value) is less than 0.05 with respect to temperature (p<0.05) which indicates that temperature has significant influence on the moisture content and colour attributes of vegetable chutney powder while the p-value with respect to thickness has no significant effect on the moisture content and colour value (A-value) as given in Tab. 4.

Table 4. ANOVA for effect of process parameters on moisture content and colour value

Independent variables	*Moisture content*		*Colour value (A-value)*	
	Mean	*Probability*	*Mean*	*Probability*
Temperature	*5.01±0.867*	*0.000*[a]	*11.87±2.083*	*0.000*[a]
Thickness		*0.896*[b]		*0.940*[b]

[a]*- significant;* [b]*- Not significant.*

CONCLUSION

From the current study it is clear that the drying process parameters; drying temperature and thickness of vegetable puree has significant influence on the nutrient content of vegetable chutney powder. Experimental data were fit into the quadratic Equation to get the prediction Equation which will be suitable for predicting the nutrient content of the chutney powder. Numerical and graphical optimization was performed to optimize the drying process parameters. The optimum temperature of drying and thickness of vegetable chutney puree was found to be 40°C and 3mm respectively. Maximum desirability function method was used to carry out numerical optimization and was found to be 0.969. At optimized conditions the predicted values for protein and carbohydrate were found to be 0.8686 and 5.209 mg/100g of chutney powder, respectively. Experiments were conducted using the predicted values to ascertain the suitability of the model for predicting the responses. This study will be useful for developing various ready to cook instant foods, balancing the nutrient loss during the processing.

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OPTIMIZACIJA PARAMETARA PROIZVODNJE MLEVENOG POVRĆA ZA POSTIZANJE MAKSIMALNOG HRANLJIVOG SADRŽAJA

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Sažetak: Mleveno povrće je proizvod spreman za kuvanje koji je pripremljen od različitih sastojaka. Čatni pire od povrća je sušen na različitim temperaturama i različitom debljinom sloja. Metodologija površinskog odgovora je upotrebljena za određivanje uticaja temperature i debljine na kvalitet samlevene slese. Ukupno 13 kombinacija eksperimantalnih proba su urađene da bi se shvatio uticaj parametara procesa. Analizom varijanse svih zavisno promenljivih, kao što su temperature i debljina i predviđena R^2 vrednost proteina i ugljhenih hidrata bili su 0.9821 i 0.9634, redom. Dobijene su finalne optimalne vrednosti temperature i debljine od 40°C i 3 mm, redom. Vrednost boje (A-vrednost) i sadržaj vlage mlevenog povrća bio je statistički analiziran upotrebom *SPSS* 20 i zaključeno je das u obe vrednosti bile pod značajnim uticajem temperature sušenja.

Ključne reči: *metodologija površinskog odgovora, optimizacija, centralni kompozit, mleveno povrće*

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