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Effect of blanching and chemical pre-treatments on the pungency of the garlic cloves

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Abstract
The present experiment was undertaken to study the effect of different pretreatments on minimally processed garlic cloves in the Department of Pomology and Post-Harvest Technology of UBKV, Pundibari. Garlic cloves were blanched (normal, hot water, and steam) and subsequently pretreated with various chemicals. Chemicals studied in this pretreatment experiment were acetic acid in the range of 0-2%, potassium metabisulphite (KMS) in the range of 0-2000 ppm, EDTA in the range of 0-1%, and Calcium chloride in the range of 0-2%. The pretreated cloves were stored under ambient conditions (Temp 25-35 °C and RH 60-80%) for 15 days before taking observations. The change in allicin content and change in textural property of the treated clove in reference to fresh cloves were recorded as response in this optimization study.
The optimization was conducted following I- Optimal Response Surface Methodology with total 43 runs divided into 5 blocks. The mean ranges for change in pungency content after 15 days of storage were 7.5-93.5%. Model were fitted for both the response factor using Design Expert 12.0.12.0 and both the model were found to fit Quadratic equation. Numerical optimization of the model parameter was resulted into the best combination of the hot water blanching cloves and subsequently dipping in the solution of 2% Acetic acid with, 0.015 ppm potassium metabisulphite (KMS), 0.037% EDTA, and 1.891% Calcium chloride for 29.25 minutes.

Keywords: Pre-treatment, response surface methodology, optimization

1. Introduction

Allium sativum L. is a member of the family Alliaceae. It is the second most frequently cultivated allium vegetable, after the onion. It most likely originated in Central Asia, from where it rapidly spread throughout the majority of the globe. In 2021-2022, garlic production in India was estimated to be 3,207.89 lakh tonnes (APEDA 2023) [14], with a productivity of 5.08 tonnes per acre. Garlic is known for its biological properties associated with immune-enhancing function and antibacterial, antifungal, antiviral, and anticancer activity and has been extensively studied for its health benefits. The health benefits of garlic have been attributed to the distinctive organosulfur compound. Garlic, like any other Allium, is characterized by the remarkable sulphur-containing compound present in it, which gives the product its distinctive smell and pungency. The pungent flavour of garlic is caused by a chemical reaction that occurs when the garlic cells are broken. The flavour is most intense shortly after cutting or chopping but after cooking chemical reaction disappears. As per the findings of Ajami and Vazirijavid (2019) [1], the pungency of garlic decreases due to the process of roasting. The addition of raw garlic to food products yields the most desirable flavour and nutritional benefits. However, this practise is associated with elevated handling and storage expenses, as well as a storage loss rate of 35-40%.

Minimal processing, dehydration or flavour extraction reduces the weight which ultimately lowers the transportation and storage cost. However, it altered the appearance and modified the natural balance between aroma and flavour. Development in production of minimally processed products is considered as a growing sector in food retail establishments because of the associated consumer convenience of fresh produce with minimum preparation time (Tripathi *et al.*, 2013) [13]. However, cutting operations involved with the production of minimally processed vegetables led to water loss, elevation in respiration and transpiration rates and thus resulted in the growth of microflora which contributes to their spoilage and shelf life reduction (Tripathi *et al.*, 2013) [13].

The process of blanching is a significant and commonly utilised pre-treatment technique in the preparation of vegetables and fruits for further processing. The process of hot water blanching is a widely employed pre-treatment method before drying, which entails submerging fresh produce in hot water at a consistent temperature between 70 to 100 °C for a few minutes (Guida *et al*. 2013) [6]. Hot water blanching is a commonly employed technique to mitigate quality degradation through the deactivation of enzymes, eradication of microorganisms, reduction of drying time, and improvement of the quality of dried products or elimination of intercellular air from tissues. The implementation of pre-treatment techniques is a prevalent practise in the majority of drying procedures, with the aim of enhancing either the quality of the final product or the efficiency of the overall process. Pre-treatments are employed in the process of product drying to achieve a product that exhibits minimal alterations in its physical, biochemical, nutritional, and sensory characteristics, thereby ensuring its high acceptability among consumers.

Acetic acid is a fundamental carboxylic acid that holds significant importance as a chemical reagent and industrial chemical. Acetic acid is employed as an acidity regulator in the food industry, categorised under the food additive code E260. Acetic acid is employed as a preservative agent with the aim of inhibiting the proliferation of bacteria and fungi. EDTA functions as a chelating agent for metals, effectively eliminating the metal cofactors that are essential for the activity of numerous enzymes. This mechanism of action serves to impede the process of food spoilage. The study conducted by Evstatiev *et al*. (2021) [4] investigated the utilisation of EDTA salts, namely sodium and calcium, as stabilising agents and sequestrants in the food industry. The primary objective was to enhance the colour and flavour stability of food products. Sulfurization is a process employed to counteract bacterial and fungal growth, as well as to impede enzymatic browning. This technique is utilised to preserve oxidizable substances such as ascorbic acid. Sulphite, bisulphite, and metabisulphite are commonly utilised in various forms. Potassium metabisulphite serves as a reliable and consistent source of sulphur dioxide. According to reports, calcium chloride has been identified as a potential inhibitor of the process of browning. The observed inhibitory effect can be attributed to the process of chelation, wherein amino acids bind with calcium. The reduction of water activity by sodium chloride has the ability to either eliminate or restrict the proliferation of microorganisms responsible for foodborne illnesses and spoilage. The application of pre-treatments in the course of postharvest processing is known to exert an influence on the chemical constituents of a given commodity.

2. Materials and Methods

2.1. Raw Material

The marketability of white garlic is enhanced by its aesthetic appeal. The experiment included white garlic that was locally sourced and possessed a visually appealing, sizable morphology. Cloves have a moderate to substantial size, possess a white coloration, and are typically found in quantities averaging 30 per bulb. The bulbs were procured from the University of Uttar Banga Krishi Viswavidyalaya in Coochbehar, West Bengal. Prior to the commencement of the study, the bulbs were subjected to shading. Subsequently, the garlic bulbs underwent a grading process, wherein solely medium-sized bulbs within the weight range of 25-32 g and measuring 40-50 mm were selected for inclusion in the study. The garlic bulbs were stored at ambient conditions in the conducted studies. The experimental methodology encompassed the hand fragmentation and removal of outer layers from garlic bulbs, employing cloves of moderate size measuring approximately 6±1 mm in diameter. Subsequently, the garlic cloves were subjected to blanching in hot water and steam for a duration of 4 minutes, as outlined by Fante and Norena (2015) [5], utilizing a digital water bath. This was then followed by a treatment including immersion in cold water. The garlic cloves were subjected to blanching and subsequently positioned on absorbent paper for a duration of 15 minutes in order to eliminate any surplus moisture. Subsequently, the garlic cloves underwent chemical pre-treatment and sanitation processes in order to mitigate the risk of microbial infection.

2.2. Standardize the pre-treatment for the garlic cloves

The experiment was conducted to standardize the blanching process, concentration of the pre-treatment and dipping time for the garlic cloves. This experiment was carried out in three replications for each run for the determination of pungency of the garlic cloves.

2.3. Preparation of pre-treatment solution

Food preservatives are compounds that are purposely added to food in order to enhance the product's shelf life and improve or change its qualities, such as flavour, appearance, or structure, provided that doing so does not reduce the food's nutritional value. Preservatives can be natural or synthetic origin that are often added in small quantity during processing. The food preservatives used in the experiment was Acetic acid, Salts of Ethylene diamine tetra acetic acid (EDTA), Potassium metabisulphite (KMS), and Calcium chloride. Pre-treatment solutions were prepared by dissolving the required amount of solute and solvent in the double distilled water. The solutions were prepared fresh, just before the blanching of garlic cloves. Measurement of weight for solution preparation was done using an analytical balance Mettler-Toledo.

2.4. Experimental Activities

The garlic cloves of uniform size were collected and blanching of the cloves were done in before pre-treatment. The pre-treatment solution was carried out in 250ml beakers. Around 100ml of the designated concentrated solution is prepared for pre-treating the garlic cloves. Around 20 numbers of cloves were dipped in the solution for a range of 15 – 60 minutes. The cloves after removing from the solution were spread over a blotting paper to remove the adhering solution. The treated samples were taken for the measurement of pungency of the cloves with the reference of fresh cloves after the storage of 15 days.

2.5. Experimental Design

A number of factors such as amount of each chemical i.e., Acetic acid, EDTA, KMS Calcium chloride, dipping time and the method of blanching technique. These are subjected to for optimization of the pre-treatment solution for the minimal processing of the garlic cloves. Therefore, a RSM design was used to identify the relationship between the response function and the process variables (concentration of the chemicals, dipping time and method of blanching technique). The experimental range of the selected process variables with their units and notation is given in Table 1. The response variables studied in the experiments were percent change in pungency of the treated clove after the storage of 15 days can be expressed as a function of the independent process variables according to the following response surface quadratic model:

Table 1: Selection of the blanching, chemicals for the pre-treatment and duration of the dipping time

Chemicals used for pretreatment	Concentration	Dipping Time	
		Minimum	Maximum
Acetic Acid (%)	0-2	15 minutes	60 minutes
KMS (PPM)	0-2000	15 minutes	60 minutes
Calcium Chloride (%)	0-2	15 minutes	60 minutes
EDTA (%)	0-1	15 minutes	60 minutes
Method of blanching: Hot water blanching (H) (90 °C for 3min), Steam Blanching (S) (at atmospheric pressure for 3 min) and No blanching (N)			

2.6. Pungency of the cloves

Pungency was estimated according to method described by Ketter and Randle (1998) [8]. Assessment of pungency was made by measuring pyruvate, which was formed as a stable primary compound from the enzymatic decomposition of each of the flavour precursors. Pyruvate was produced in a mole for mole relationship with the flavour precursors. While estimating the pungency of the cloves the standard curve was plotted by using sodium pyruvate. Sodium pyruvate of different concentrations are prepared from the stock solution of 0.1 M. The different concentrations of the pyruvate ranges from 5 µ moles/ml to 30 µ moles/ml and absorbance of the values were recorded and plot the standard curve. For the estimation of the pungency from the garlic sample, firstly the two gram of garlic cloves were taken and crushed in the mortar and pestle with double distilled water. The mixture was collected in a beaker and covered with glass lid. Pipette out the 0.5 ml of garlic slurry into a large test tube. Then add 1.5 ml of 5% trichloroacetic acid and 18 ml distilled water was added and covered with parafilm and vortex for 2-3 minutes and allowed sit for 1 hour. From the prepared mixture 1 ml was taken into test tube and then 1 ml each of 0.125% of 2,4 dinitrophenylhydrazine (DNPH) in 2 N hydrochloric acid (HCl) and 1ml of distilled water was added and samples were incubated at 37 °C for 10 minutes. Later, the DNPH reacts with pyruvate in the sample after the addition of 5 ml of 0.6 N of NaOH was added into the sample. NaOH giving a brown coloured hydrazone product where the absorbance was measured in spectrophotometer having model number UV-1900i UV Visual Spectrophotometer of SHIMADZU at 420 nm using blank (without sample). The result was expressed change in pungency in terms of percentage with reference to fresh clove.

A total of 43 experiment runs were replicated thrice performed according to the I- optimal response surface methodology in Table 2 and the average values were used in data analysis. The experimental data were analysed by the software, Design Expert Version 12.0.1.12 (Stat-Ease, USA). The adequacy of the developed model and statistical significance of the regression coefficients were tested using the analysis of variance (ANOVA). The interaction among the different independent variables and their corresponding effect on the response was studied by analysing the response surface.

3. Results and Discussion

The objective of design analysis is to determine which model can be used to fit the experimental data appropriately. To judge the adequacy of the fitted regression model for pungency of the cloves, various statistical test was performed and the result obtained from these test was presented in Table. 2 The quadratic model appears to adequately represent the true response surface based on its insignificant lack-of-fit (p>0.05) with sequential p-value of less than 0.05. Furthermore, the quadratic model has the highest $R2$, adjusted $R2$ and predicted $R2$ for pungency of the cloves.

3.1. Development of mathematical model using I-optimal response surface design

To develop mathematical models for the pre-treated cloves, a quadratic function was used to determine the relationships between the input variables (X_i) and the output responses (Y). The response function representing pungency of the pre-treated cloves, can be described as in: The quadratic surface response model can be expressed as in equation:

$$Y = \beta o + \sum_{i=1}^{n} \beta_{ii} X_i^2 + \sum_{\substack{0 \le i \le m \\ 0 < j < n}} \beta_{ij}(i,j)$$

Where Y refers to the observed response in relation to independent variables X_i and X_j

In garlic pungency plays a crucial role in the evaluation of quality of the product. The sensation of pungency arises as a result of the mechanical disruption of cells, which can occur through various means such as cutting or macerating. The percentage decrement of pungency of the garlic clove was determined as per the procedure explained in Section 2.6. Based on the data presented in Table 4.1, it was evident that the pungency of the pre-treated garlic cloves exhibited a percentage decrement ranging from 7.54 – 93.53% across all experimental conditions. The experimental run number 9 of first block of second group exhibited the greatest reduction in pungency in relation to fresh clove. This decrease was observed in independent variables of steam blanched cloves dipped for 15 minutes in the concentration of the pre-treatment solution of 2000 ppm of KMS, 1% of EDTA and calcium chloride of 2%. Conversely, a minimal reduction in pungency was observed during the fifth block of nineth group in the experiment run number 37, where the garlic cloves were dipped for 15 minutes in the concentration of acetic acid 2%, 2000 ppm of KMS, EDTA 2% and 2% of calcium chloride. Similar results were report by Cui *et al.* (2003) [3] on the pungency of garlic by loss around 45.84%. The degradation of the pungency of the garlic cloves was reported by Rejano *et al.* (2004) [11] in the thermal kinetics study. According to the findings of Locatelli *et al.* (2015) [9], the complete elimination of all organosulfur compounds (OSCs) in garlic cloves was seen subsequent to a 10-minute duration of boiling in water. According to a prior investigation conducted by Tocmo *et al.* (2017) [12], the process of boiling water has been shown to cause the degradation of allicin into

DADS and DATS, thereby leading to an elevation in linear polysulfides. Recent studies have indicated a decrease in bioactive chemicals, such as allicin, total phenolics, total flavonoids, and anthocyanins, during the drying process of fruits and vegetables (Chen *et al.* 2020, Kayacan *et al.* 2020) [2, 7]. The potential cause for the reduction in allicin content might be attributed to the degradation process occurring during heat treatment. Ratti *et al.* (2007) [10] discovered a similar outcome, whereby the allicin concentration declined as the temperature increased in hot air-drying process. It was shown that moderate air temperatures (40 and 50 °C) facilitated improved allicin preservation, approaching the levels reported in fresh garlic.

3.2 Statistical and numerical analysis of pungency of pre-treated garlic cloves

The primary objective of this study was to conduct a comprehensive analysis of experimental data in order to carefully observe and examine the effect of different independent parameters on the pungency levels exhibited by garlic cloves. The above mentioned parameter encompassed with the quantitative aspects of the experiment, namely the concentration of acetic acid, the parts per million of KMS, the percentage of EDTA, the concentration of $CaCl_2$, the blanching method (H, N, S), and the duration of dipping in minutes. In order to determine the impacts of numerous independent factors on the pungency of the garlic cloves this research analysed experimental data in table no 2.

Table 2: Experimental results of responses for standardization of the pre-treatment for garlic cloves.

			Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Response 1
Run	Block	Group	A: Acetic acid	b: KMS	C: EDTA	D: Calcium chloride	E: Dipping Time	F: Blanching	Change in Pungency
			%	ppm	%	%	min		%
1	Block 1	1	2	0	0	0.2	50	S	23.61
2	Block 1	1	0	0	0	2	15	S	63.68
3	Block 1	1	0	0	1	2	60	H	34.67
4	Block 1	1	0.8	0	1	2	60	S	88.58
5	Block 1	2	0	1070	0.1	0	60	S	35.75
6	Block 1	2	2	1070	1	0	15	S	93.21
7	Block 1	2	0.9	1070	0.4	2	15	N	47.33
8	Block 1	2	1	1070	0	0.9	38	N	53.35
9	Block 2	3	0	2000	1	2	15	S	93.53**
10	Block 2	3	1.4	2000	1	0.1	60	S	78.46
11	Block 2	3	0	2000	1	0	40	N	35.56
12	Block 2	3	2	2000	0.6	2	40	S	49.59
13	Block 2	4	2	0	0.7	1.7	18	S	58.47
14	Block 2	4	0	0	0.4	2	60	N	49.43
15	Block 2	4	0.2	0	1	1	15	N	40.18
16	Block 2	4	0.5	0	0.7	0	29	S	90.19
17	Block 2	4	1	2000	0.8	0.8	15	H	71.46
18	Block 3	5	2	2000	0.3	1	60	N	37.22
19	Block 3	5	1.3	2000	0.3	1.2	23	S	56.26
20	Block 3	5	0	2000	0.3	1.2	60	H	35.33
21	Block 3	5	0	940	0.6	1	39	S	52.70
22	Block 3	6	0.5	940	0	0	60	N	52.07
23	Block 3	6	0.9	940	0.5	2	42	H	48.68
24	Block 3	6	0	940	0	0	15	H	70.01
25	Block 3	6	1.5	0	0.5	0	15	H	69.78
26	Block 4	7	2	0	0.6	1.3	60	H	35.39
27	Block 4	7	0.4	0	0	1.4	45	H	30.23
28	Block 4	7	2	0	0	2	34	N	52.34
29	Block 4	7	2	0	1	0	52	N	28.59
30	Block 4	7	0.5	990	1	1.5	60	N	58.76
31	Block 4	8	0	990	0.4	0.4	15	N	54.18
32	Block 4	8	1.5	990	0	2	60	S	83.16
33	Block 4	8	2	990	1	0.9	35	H	34.20
34	Block 4	8	0	990	1	2	21	H	34.21
35	Block 5	9	0.4	2000	0	0	15	S	48.04
36	Block 5	9	2	2000	1	2	60	H	62.65
37	Block 5	9	2	2000	1	2	15	N	7.54*
38	Block 5	9	2	2000	0	0	48	H	23.98
39	Block 5	10	0	2000	0	2	43	N	36.39
40	Block 5	10	1.2	1100	0.7	1	42	N	35.48
41	Block 5	10	2	1100	0	2	15	H	37.96
42	Block 5	10	0.9	1100	0.5	0	45	H	68.47
43	Block 5	10	2	1100	0	0	15	N	28.36

*Indicates the minimum value, ** indicates the maximum value

N indicates No Blanching, H indicates Hot water Blanching and S indicates Steam Blanching

The results obtained for the percentage decrement for the pungency of the pre-treated cloves was shown in table no 2 revealed that independent factors having Acetic acid (A), EDTA (C), and Blanching (F) had significant effect at 5% level of significance expect KMS (b) and Calcium chloride (D).

Table 3: Analysis of variance for pungency of the pre-treated garlic cloves.

Source	Term df	Error df	F-value	p-value	
Subplot	32	10.00	21.48	< 0.0001	Significant
A-Acetic acid	1	10.00	22.57	0.0008	Significant
b-KMS	1	10.00	4.55	0.0588	Not significant
C-EDTA	1	10.00	46.65	< 0.0001	Significant
D-Calcium chloride	1	10.00	4.43	0.0617	Significant
E-Dipping Time	1	10.00	0.1865	0.6750	Not significant
F-Blanching	2	10.00	74.52	< 0.0001	Significant
Ab	1	10.00	0.1492	0.7074	Not significant
AC	1	10.00	11.85	0.0063	Significant
AD	1	10.00	20.58	0.0011	Significant
AE	1	10.00	15.66	0.0027	Significant
AF	2	10.00	0.0651	0.9374	Not significant
bC	1	10.00	8.46	0.0156	Significant
bD	1	10.00	10.53	0.0088	Significant
bE	1	10.00	0.0096	0.9239	Not significant
bF	2	10.00	7.45	0.0105	Significant
CD	1	10.00	41.72	< 0.0001	Significant
CE	1	10.00	0.0038	0.9519	Not significant
CF	2	10.00	51.22	< 0.0001	Significant
DE	1	10.00	28.39	0.0003	Significant
DF	2	10.00	17.11	0.0006	Significant
EF	2	10.00	17.33	0.0006	Significant
A^2	1	10.00	64.61	< 0.0001	Significant
b^2	1	10.00	16.45	0.0023	Significant
C^2	1	10.00	4.90	0.0512	Not significant
D^2	1	10.00	9.14	0.0128	Significant
E^2	1	10.00	51.52	< 0.0001	Significant
Std. Dev.	5.05				
Mean	50.91				
C.V. %	9.92				
R^2	0.9857				
Adjusted R^2	0.9140				

The statistical analysis revealed that several interaction terms, namely acetic acid and EDTA (AC), acetic acid and calcium chloride (AD), acetic acid and dipping time (AE), KMS and EDTA (bC), KMS and calcium chloride (bD), KMS and blanching (bF), EDTA and calcium chloride (CD), EDTA and blanching (CF), calcium chloride and dipping time (DE), calcium chloride and blanching (DF), and dipping time and blanching (EF) exhibited a significant impact on the pungency of clove at a significance level of $p<0.05$. The quadratic coefficients associated with acetic acid, KMS, calcium chloride, and dipping time exhibit statistical significance. The remaining interaction and quadratic terms were determined to have a statistically insignificant impact ($p<0.05$) on the pungency of garlic cloves.

The model's adequacy was assessed through the utilisation of a numerical method, specifically by employing R^2 and R^2 adjusted. The data was subjected to regression analysis in order to model the percent reduction in pungency of the pre-treated cloves. The R^2 value of 0.9857 and the adjusted R^2 value of 0.9140 suggest a strong correlation between the observed and predicted values. The overall variance resulting from the model has been determined to be 25.52 with a zero variance was attributed to the block and group, and a residual variance of 25.52. The C.V of the model was 9.52%. The model was fit to use.

The utilisation of a second order mathematical equation was employed to appropriately model the percent reduction in pungency experimental data. This approach facilitated the examination of the empirical relationship that exists between the response and process variables, which were represented in their coded form. By excluding the non-significant terms from the model, we can observe that the regression equation provided elucidates the impact of significant input test variables on the percentage reduction in pungency of the pre-treated garlic cloves.

$$P = 50.58 - 4.967A + 7.126C - 11.2363F^{[1]} - 1.68709F^{[2]} - 4.71AC + 6.225AD + 5.204AE + 3.97bC + 4.977bD - 3.157bF^{[1]} + 5.841bF^{[2]} - 9.786CD - 13.311CF^{[1]} + 0.9744CF^{[2]} + 7.574DE + 4.249DF^{[1]} - 10.017DF^{[2]} + 6.595EF^{[1]} + 2.074EF^{[2]} - 16.765A^2 - 7.580b^2 + 6.29267D^2 + 14.950E^2 \quad \text{.............................Eq. No: 1}$$

Where, P is the pungency, A is the acetic acid, b is the KMS, C is the EDTA, D is the calcium chloride, E is the dipping time and F is the blanching method.

The coefficients of pungency was expressed in equation no 1 provide information about the impact of the independent variables on the pungency of the pre-treated garlic cloves, as indicated by their sign and magnitude had a intercept of ß coefficient 50.58. In the equation of the pungency describes the relationship of the acetic acid (-4.967) had a negative coefficient which indicates that a decrease in pungency loss with the increase in parameter level. The coefficient of EDTA (7.126) had a positive coefficient in the models which indicates the more percent reduction in pungency will exhibit when the concentration of the chemicals increased. The blanching type had exhibited negative coefficients. At the level of interaction, it was observed that the combination of acetic acid and calcium chloride (6.225), acetic acid and dipping time (5.204), KMS and EDTA (3.97), KMS and calcium chloride (4.977), KMS and Blanching (5.841,bF2), EDTA and blanching (0.9744,CF2), calcium chloride and dipping time (7.574), calcium chloride and blanching (4.249, DF1), dipping time and blanching (6.595, EF1), and dipping time and blanching (2.074, EF2) exhibited a positive correlation with percentage reduction in pungency, while the remaining interaction terms acetic acid and EDTA (-4.714), KMS and blanching (-3.157, bF1), EDTA and calcium chloride (-9.786), EDTA and blanching (-3.311,CF1), calcium chloride and blanching (-10.0174,DF2) demonstrated a negative correlation. At the quadratic level, a positive coefficient was observed in the Calcium chloride (6.292) and dipping time (14.9501) which indicates the increase in the concentration of the chemical and dipping time leads to increase in the change in pungency of the pre-treated garlic cloves. A negative coefficient of acetic acid (-16.765), and KMS (-7.580) indicates that an increase in their levels leads to a decrease in the percentage loss of pungency from the garlic cloves.

3.3. Graphical Interpretation of Responses

The standardisation of the pre-treatment solution for garlic cloves was determined through statistical analysis, numerical analysis, and optimisation of the different process parameters. The regression analysis of each response revealed a significant effect on the p value at the 1% and 5% levels of significance. The impact of the variables on the responses considered for the pre-treatment solution were analysed through graphical analysis. This involved creating factor or linear plots and contour plots to examine how the different responses change in relation to the significant process variables. The plots were generated using Design Expert 12.1.12.0 software. The contour plot visually represents the nature and magnitude of interactions among the various process parameters in relation to their respective responses.

Experimental design and optimization use response surface graphs to show the association between numerous independent parameters and a response variable. Response surface graphs are used to show the association between multiple independent factors and one dependent variable. The clove pungency characteristics are the independent variables in this scenario. Acetic acid and KMS (potassium metabisulfite) alter the response surface in Figure 1.1a. The quadratic response surface suggests that the two factors interacted to affect clove pungency. The quadratic response suggests an optimum acetic acid and KMS combination for maximum pungency reduction. Acetic acid and KMS at optimal amounts reduce pungency by a large percentage. This means that when the above variables are adjusted to their perfect values, the cloves have less pungency than other combinations. Acetic acid and KMS concentrations at its lowest have little effect on pungency %.

Figure 1.1b shows the response surface plots showing how acetic acid and EDTA affect clove pungency. The response surface shows a quadratic relationship between clove pungency and the two parameters. The percent clove pungency decrease was highest at the optimal acetic acid and EDTA levels. When using larger acetic acid concentrations and the appropriate EDTA level, the percentage reduction of pungency was limited. Figure 1.1c shows the response surface plots, which show how acetic acid and calcium chloride affect clove pungency. The clove's pungency intensity and the two independent variables' influence are quadratic, according to the response surface. The study found that optimising acetic acid and minimizing calcium chloride reduced clove pungency the most. However, using optimal to higher calcium chloride concentrations and meeting the minimum acetic acid threshold resulted in a minor decrease in pungency.

Figure 1.1d shows the response surface plots, which indicate how acetic acid concentration and dipping duration affect clove pungency. The response surface reveals a quadratic relationship between clove pungency and the combined influence of the two independent factors. The research found that cloves' pungency was reduced most when acetic acid concentration was maximized and dipping time was maximized. A study found that cloves with optimal to high acetic acid concentrations had the lowest % drop in pungency and the shortest dipping time.

The response surface graph in Figure 1.1e shows how KMS and EDTA affect garlic clove pungency. The graphical representation shows a linear relationship between independent and response variables. The percentage reduction of pungency was greatest when KMS and EDTA were used at higher quantities. The cloves' pungency was minimal when KMS was low and EDTA was high.

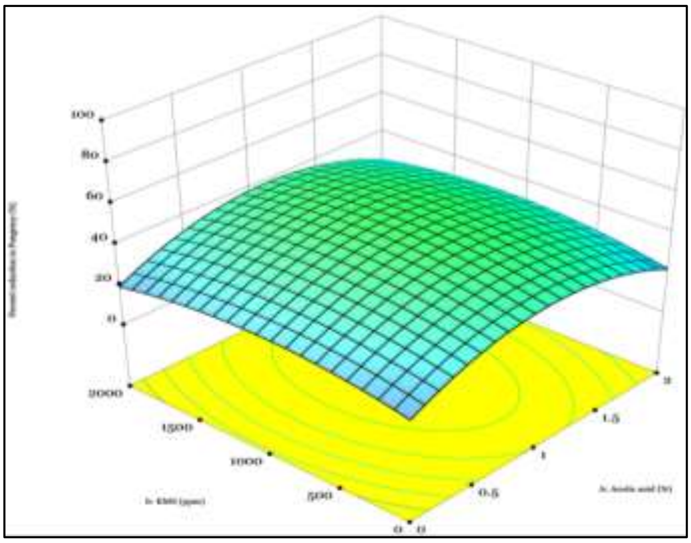
The response surface graph in Figure 1.1f shows how KMS and calcium chloride affect garlic clove pungency. The graph shows a quadratic association between independent factors and response variable. When using higher doses of potassium metabisulfite (KMS) and calcium chloride, pungency percentage decreased significantly. The cloves' pungency was minimally affected by increasing KMS and lowering calcium chloride.

Figure 1.1g shows reaction surface plots, which help explain how KMS concentration and dipping time interact. These factors significantly affect clove pungency. The response surface plot shows a quadratic link between clove pungency and the two independent parameters. The study found that optimising KMS concentration and dipping cloves for the longest time lowered their pungency. However, the result that low potassium metabisulfite (KMS) and brief clove immersion reduced pungency was notable.

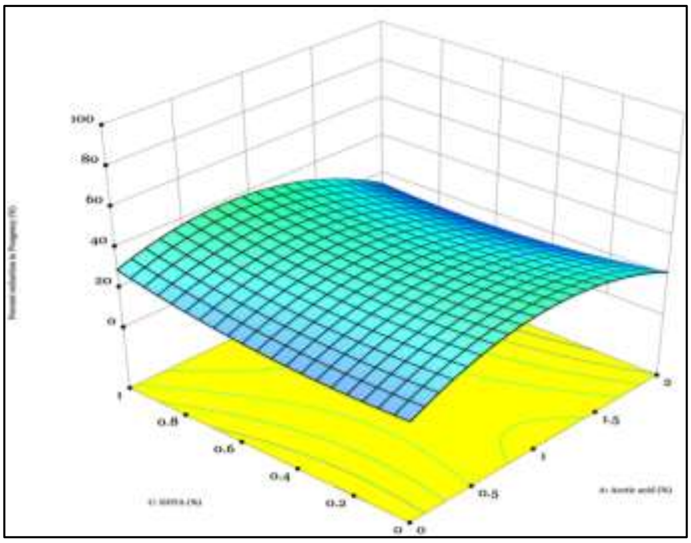
Figure 1.1h shows the response surface plots, which indicate how EDTA and calcium chloride affect clove pungency. The response surface suggests a linear association between clove pungency and the two independent factors. The study found that maximizing EDTA and minimizing calcium chloride reduced clove pungency. However, employing more calcium chloride and EDTA reduced pungency slightly.

The response surface plots in Figure 1.1i are pictorial. These charts reveal how EDTA concentration and dipping time interact. The above elements greatly affect clove pungency. The response surface showed a quadratic association between clove pungency decrease and the two independent factors. The study found that using a low EDTA concentration and submerging cloves for a long time reduced their pungency the most. Garlic cloves immersed in greater EDTA concentrations showed a significant marginal decrease in pungency.

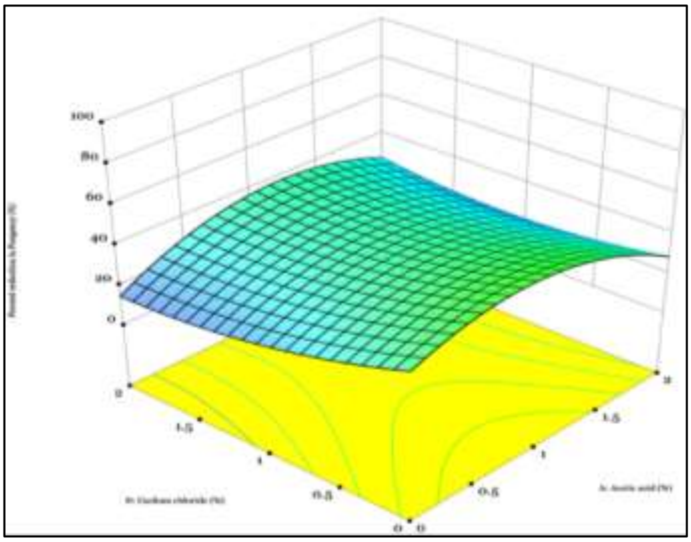
Figure 1 a-j shows response surface plots. The response surface showed a strong association between calcium chloride concentration and length time. The above factors significantly affected clove pungency. According to the response surface, the percentage reduction in clove pungency and the combined influence of the two independent variables are quadratic. The study found that cloves' pungency decreased with higher calcium chloride concentrations and longer immersion times. When cloves were soaked for a short time in optimal to maximal calcium chloride, pungency reduction decreased.



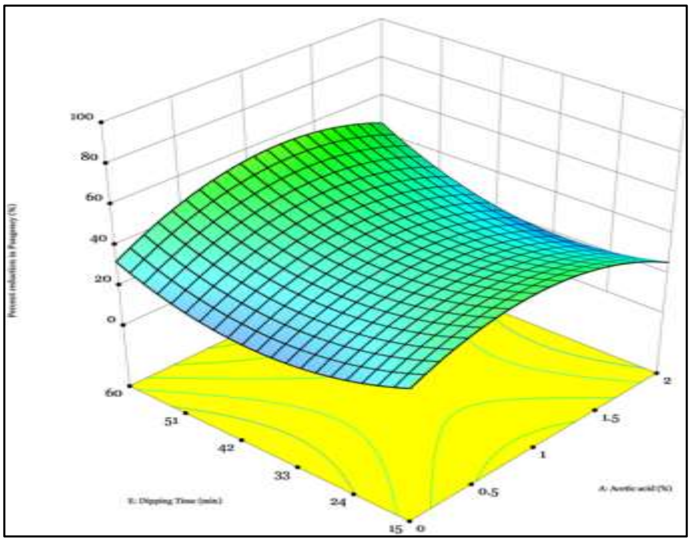
(a)



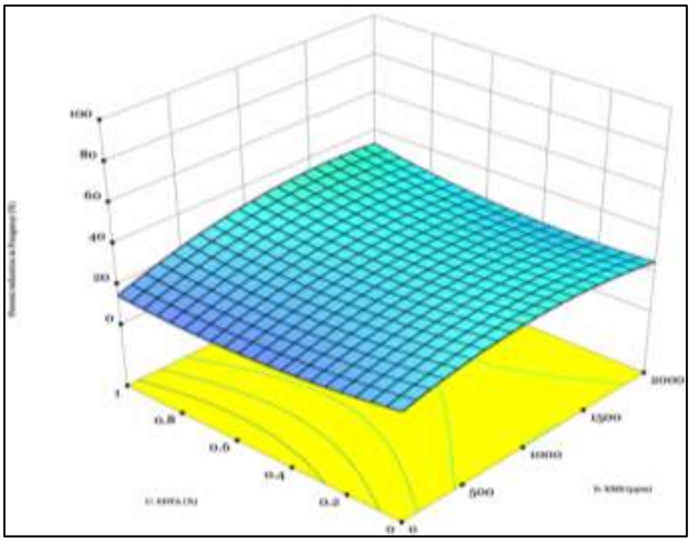
(b)



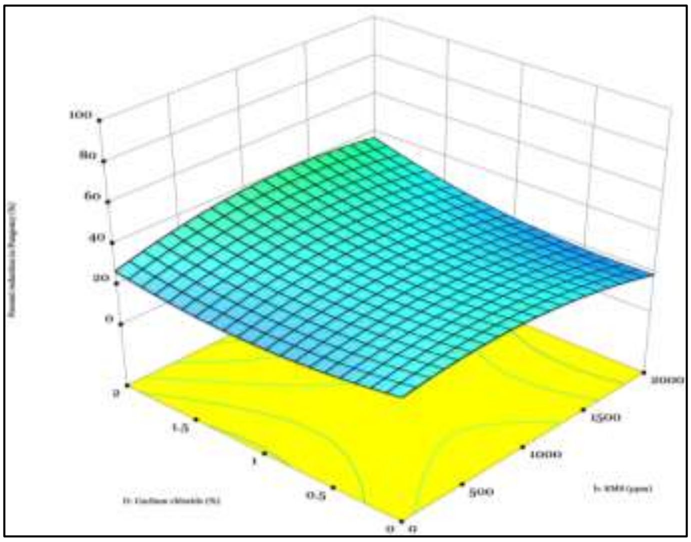
(c)



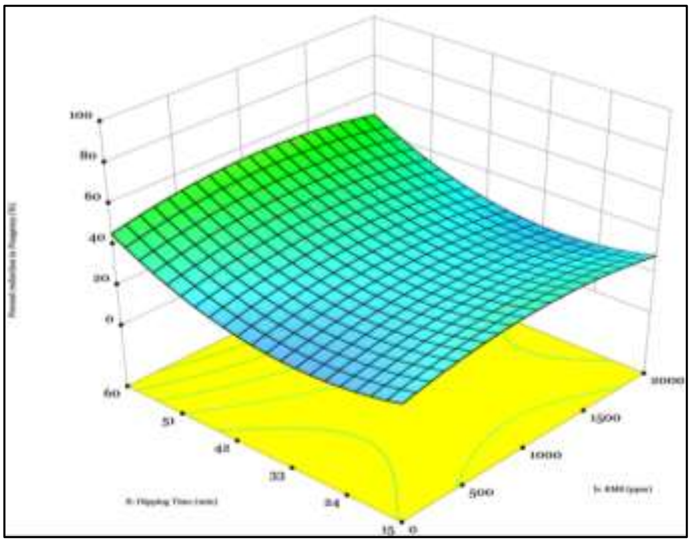
(d)



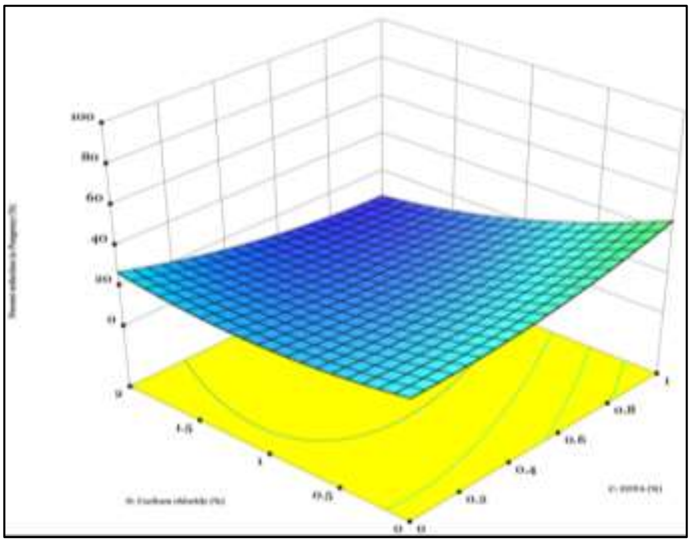
(e)



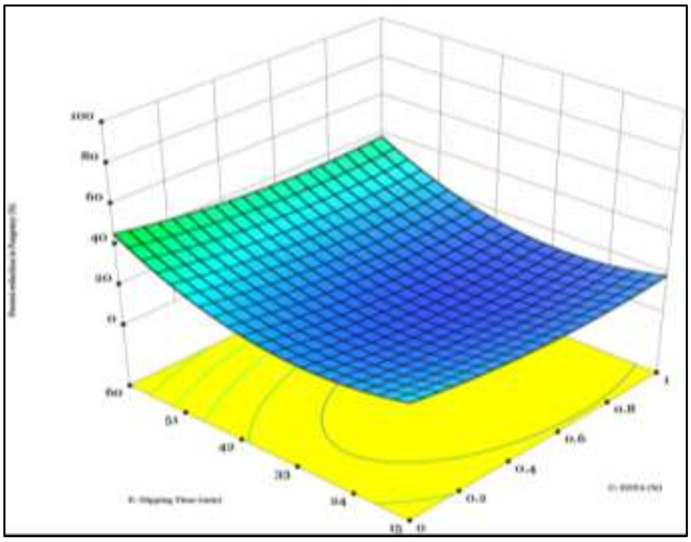
(f)



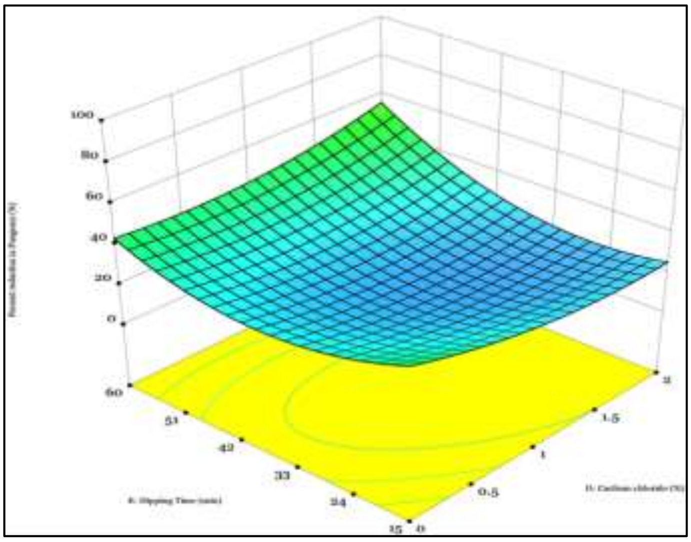
(g)



(h)



(i)



(j)

Fig 1: Graphical representation of the pungency of the pre-treated garlic cloves (a- j)

Conclusion

In order to optimise the process parameters, the objective was established within a range for variables such as acetic acid, KMS, EDTA, calcium chloride dipping time, and blanching method. The dependent variable pungency was set to be minimised. The response and independent variables were assigned equal importance. Based on this criteria used to establish a goal for optimising process parameters in order to standardise the pre-treatment solution for garlic cloves. The optimisation process was conducted in accordance with the specified criteria. A total of 100 potential solutions were identified, from which the most optimal pre-treatment solutions was selected based on their alignment with the established criteria was resulted into the best combination of the hot water blanching cloves and subsequently dipping in the solution of 2% Acetic acid with, 0.015 ppm potassium metabisulphite (KMS), 0.037% EDTA, and 1.891% Calcium chloride for 29.25 minutes with a desirability of 0.832. The chosen solution was deemed the most desirable among the other available alternatives. The optimized process combination under each chemical was used for pre-treatment concentration of garlic cloves for dehydration study.

References

1. Ajami M, Vazirijavid R. National Nutrition and Food Technology Research Institute, Shahid Beheshti University of Medical Sciences, Tehran, Iran, Payam Noor University of Tehran, Tehran, Iran Nonvitamin and Nonmineral Nutritional Supplements; c2019. https://doi.org/10.1016/B978-0-12-812491-8.00033-3.
2. Chen YN, Li M, Dharmasiri TSK, Song, XY, Liu F, Wang X. Novel ultrasonic-assisted vacuum drying technique for dehydrating garlic slices and predicting the quality properties by low field nuclear magnetic resonance, 2020. Food Chemistry, 306, Article 125625.
3. Cui ZW, Xu SY, Sun DW. Dehydration of garlic slices by combined microwave-vacuum and air drying. Drying technology. 2003;21(7):1173-1184.
4. Evstatiev R, Cervenka A, Austerlitz T, Deim G, Baumgartner M, Beer A, *et al*. The food additive EDTA aggravates colitis and colon carcinogenesis in mouse models. Scientific reports. 2021;11(1):5188.
5. Fante L, Noreña CP. Quality of hot air dried and freeze-dried of garlic (*Allium sativum* L.). Journal of Food Science and Technology. 2015;52:211-220.
6. Guida VG, Ferrari G, Pataro A, Chambery A, Maro D, Parente A. The effects of ohic and conventional blanching on the nutritional, bioactive compounds and quality parameters of artichoke heads. LWT – Food Science and Technology. 2013;53(2):569-579.
7. Kayacan S, Karasu S, Akman PK, Goktas H, Doymaz I, Sagdic O. Effect of different drying methods on total bioactive compounds, phenolic profile, in vitro bioaccessibility of phenolic and HMF formation of persimmon. LWT – Food science and Technology; c2020, 118, Article 108830.
8. Kettler CAT, Randle WM. Pungency assessment in onions. Proceedings of the 19th workshop/ conference of the association for biology laboratory education. 1998, 177-196.
9. Locatelli DA, Altamirano JC, González RE, Camargo AB. Home-cooked garlic remains a healthy food. Journal of Functional Foods. 2015;16:1-8. https://doi.org/10.1016/j.jff.2015. 04.012.
10. Ratti C, Araya-Farias M, Mendez-Lagunas L, Makhlouf J. Drying of garlic (*Allium sativum*) and its effect on allicin retention. Drying technology. 2007;25(2):349-356.
11. Rejano L, Castro AD, Sánchez AH, Casado FJ, Montaño A. Thermal kinetics of pungency loss in relation to the quality of pickled garlic. International Journal of Food Science and Technology. 2004;(3):311-317.
12. Tocmo R, Wu Y, Liang D, Fogliano V, Huang, D. Boiling enriches the linear poly- sulfides and the hydrogen sulfide-releasing activity of garlic. Food Chemistry. 2017;221:1867-1873. https://doi.org/10.1016/j.foodchem.2016.10.076.
13. Tripathi J, Chatterjee S, Vaishnav J, Variyar PS, Sharma A. Gamma irradiation increases storability and shelf life of minimally processed ready-to-cook (RTC) ash gourd (*Benincasa hispida*) cubes. Postharvest Biology and Biotechnology. 2013;76:17-25. https://doi.org/10.1016/j.postharvbio.2012.09.001
14. APEDA.https://agriexchange.apeda.gov.in/India%20Production/India_Productions.aspx?hscode=1100.2023.