International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(6): 1054-1057

Received: 16-09-2019
Accepted: 18-10-2019

IA Ansari
Assistant Professor, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, India

Niman Bodra
M. Tech student, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, India

Pramod Rai
Assistant Professor, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, India

Suman Tigga
M. Tech student, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, India

Izhar Sabri
Senior Research Fellow, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, India

Corresponding Author:
IA Ansari
Assistant Professor, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, India

Optimization of operating conditions of dehydration of green chilli

IA Ansari, Niman Bodra, Pramod Rai, Suman Tigga and Izhar Sabri

Abstract
Dehydration is used to increase the shelf life of fruits and vegetables by minimizing moisture mediated undesirable changes. In this study, green chilli was used for dehydration to increase the shelf life with acceptable quality attributes. The experiments were conducted according to Central Composite Rotatable Design (CCRD). The dehydration conditions were optimized by using response surface methodology. The independent variables taken were size (5 mm-15 mm)and hot air temperature (50 ^{0}C -70 ^{0}C). The response variables selected were drying time, rehydration ratio and visual colour. The optimized values of drying air temperature and size were found to be 53 ºC and 13.5 mm respectively at desirability value of 0.60. At this optimum operating conditions, the drying time, rehydration ratio and visual colour on 5 Hedonic scale were found to be 5.2 hours, 5.68 and 1.55 respectively. The optimized drying conditions could be utilized for dehydration of green chilli.

Keywords: Green chilli, dehydration, response surface methodology, optimization, rehydration ratio, visual colour

Introduction

Green chillies are one of the most valuable crops of India. The production of green chilli is increasing at rapid pace due to advancement production technology and higher consumption. Chilli is cultivated in almost all the states in India but, Andhra Pradesh is the largest producer accounting for more than 50% of total chilli output of the country. Chillies contain health benefiting alkaloid compound. Capsaicin present in chilli gives strong spicy pungent taste. Chillies are excellent source of vitamin A, B, C and E with minerals like molybdenum, manganese, folate, potassium, thiamine and copper (Kumar *et al*; 2017). Green chillies have a foaming property which is important in cake preparation, whipping, and topping (Kinsella, 1979) [6].

The shelf life of freshly harvested chilli is limited to 2–3 days due to its initial high moisture content (Kaleemullah and Kailappan, 2006) [5]. Green chillies are highly perishable and sometimes farmers get very less profit due to the glut in the market during the main seasonal harvests. A huge amount of green chillies is wasted due to lack of proper preservation techniques (Shanmughavelu, 1989) [10]. It respires after harvest and due to high respiration rate, there is a buildup of temperature, which adversely affects the quality attributes of chilli which ultimately results in short post-harvest life. Microbial, enzymatic and chemical reaction, discolouration, textural changes are the factors which lower their quality and thus influences the consumers decision of acceptance. Fresh green chillies undergo high postharvest losses due to poor postharvest handling during transportation and storage (Singh *et al.*, 2009) [9]. The feasibility of green chilli processing and preservation in the form of powder has been reported by Tummala *et al*. (2008) [12]. The increasing demand of processed ready to eat and ready to cook products has resulted in growing industry of Indian spices. There are different techniques of extending shelf life of green chilli such as canning, freezing and dehydration. Dehydration is the oldest and easiest method of food preservation in comparison to other methods. The basic aim of the drying process is the removal of water from the food products up to a level, at which microbial spoilage and deterioration are minimal (Cohen and Yang, 1995) [2]. Removal of moisture prevents the growth and reproduction of decay causing microorganisms and minimizes many moisture induced deteriorative reactions. Dehydration also brings about substantial reduction in weight and volume. This reduces packaging, storage and transportation costs and enables storability of the product under ambient temperature. Longer shelf life, product diversity and substantial volume reduction are the reasons for popularity of dried fruits

(Jasim and Shivare, 2001) [4]. The drying of chilli is essential to enhance keeping quality and making available round the year. Drying is one of the important unit operations in food industry. Among various hot air drying, the hot air oven drying is common method for small scale drying. Siriwattananon and Maneerate (2016) [11] have reported that the hot air oven drying is widely used in small enterprises or factories as it is advantageous for quality control. The optimum drying conditions for green chilli is essential for getting the quality of end product with minimum changes during subsequent storage period. The main objective of this study to explore the optimum conditions for drying of green chilli.

Material and Methods

Raw material and sample preparation

Fresh green chillies were obtained from Research Farm, Birsa Agricultural University, Ranchi and stored at 4 to 5 ^{0}C temperature in a refrigerator. Prior to experiments, green chillies were thoroughly washed to remove the sticking soil particles and graded to eliminate the variations in sizes. The size of desired length were obtained by carefully cutting the green chillies with a sharp knife.

Determination of moisture content

Moisture content of the fresh green chilli sample was determined by drying the samples in an oven at 104 °C for 24 hours. The amount of moisture evaporated was calculated and moisture content was expressed as % (w. b.). The initial moisture content of the green chilli used for this study was in range of 86- 90 % (w. b.).

Experimental plan and design

The experiments were conducted for dehydration of green chillies under hot air drying conditions in order to investigate the effect of different process variables on various quality attributes of dehydrated green chillies. The independent variables and their levels were chosen according to review of literature and some preliminary drying experiments. A hot air oven, available at the Laboratory of Post Harvest Technology, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi was used for drying of green chillies. The hot air oven was used for drying consists of an air blower, air heaters, temperature controller and two SS trays. Drying air temperature and size of green chilli were chosen as the independent variables for hot air drying with the values commonly employed for dehydration. The dependent (response) variables taken were drying time, rehydration ratio and visual colour. Thirteen experiments were conducted according to second order central composite rotatable design with two variables and five levels of each variable. Levels of independent variables are coded using following equations:

$$x_i = \frac{\varepsilon_i - central\ value}{interval\ between\ successive\ levels} \quad \text{............ (1)}$$

Where,
x_i = Coded value of the independent variable
ε_i = Actual value of the factor

$$y = a + bx_1 + cx_2 + dx_3 + ex_1^2 + fx_2^2 + gx_3^2 + hx_1x_2 + jx_2x_3 + kx_1x_3 \quad (2)$$

The independent variables and coded variables and their levels are presented in Table 1. The level combinations for a 2-factor CCRD are presented in Table 2.

Table 1: Levels of independent variables for optimization of drying conditions of green chillies

Variables	Symbol	Level				
		–1.414	**–1**	**0**	**1**	**1.414**
Air Temperature (^{0}C)	Ta	50	53	60	67	70
size (mm)	d	5	6.5	10	13.5	15

Table 2: Five level two factors experimental design for optimization of drying conditions of green chillies

Experiment No.	Air Temperature (℃) Coded and Actual	Size (mm) Coded and Actual
1	-1(53)	-1(6.5)
2	1(67)	-1(6.5)
3	-1(53)	1(13.5)
4	1(67)	1(13.5)
5	-1.414(50)	0(10)
6	1.414(70)	0(10)
7	0(60)	-1.414(5)
8	0(60)	1.414(15)
9	0(60)	0(10)
10	0(60)	0(10)
11	0(60)	0(10)
12	0(60)	0(10)
13	0(60)	0(10)

Experimental procedure

About 100g of green chilli samples were taken for dehydration studies for each experiment and experiments were carried out as per experimental design. Green chilli samples were subjected to optimized pre-drying treatment condition (potassium metabisulphite: 0.7 % and blanching 1.5 min) before drying (Bodra and Ansari, 2018) [1]**.** Before placing the samples in hot air oven, the oven was run for half an hour to stabilize the temperature of the drying air to the pre-set drying air temperature. The weight loss was evaluated at every one hour interval during drying. This was done by weighing samples outside the drying chamber, using the digital balance placed adjacent to the drying chamber. Drying was stopped when constant weight was achieved. Rehydration ratio, visual colour and drying time data were obtained for each set of drying experiment.

Visual colour

The sensory evaluations of dried samples were carried out by a panel of 10 untrained judges. The panelists were given a performa for sensory evaluation for visual colour of each sample. The sensory evaluation was performed using 5-point Hedonic scale with 10 panel members. The Hedonic scale rating used are as follows: Excellent: 1, Good: 2, Fair: 3, Poor: 4 and Very poor: 5.

Rehydration ratio (RR)

The rehydration experiments were carried out for dried samples. Dried green chillies were weighed (approx. 2g) and soaked in boiling water. The samples were weighed at every 15 min. intervals after draining excess water until constant weight was attained.

The rehydration ratio was calculated using following equation:

$$\text{rehydration ratio} = \frac{\text{weight after rehydration}}{\text{weight before rehydration}}$$

Analysis of data and response surface

Analysis of variance (ANOVA) were conducted for fitting the models represented by equation (1) and to examine the statistical significance of the model terms. The adequacies of the models were determined using model analysis, lack of fit test and R^2 (coefficient of determination) analysis. The R^2 is defined as the ratio of the explained variation to the total variation, and is a measure of the degree of fit of the model (Haber and Runyon, 1977) [3]. Response surfaces were generated and numerical optimization technique was performed by the Design-Expert software to get optimum pretreatment and drying operating condition.

Results and Discussion

Effect of process parameters on drying time

The experimental values of Td, RR and VC for various experimental conditions are presented in Table 3. The regression co-efficient was obtained by employing least square technique. The model was tested for adequacy by analysis of variance. The regression model for drying time was found to be highly significant with a coefficient of determination as 0.9483 and F value of 25.65. Similar finding was reported by Raj *et al*. (2013) [8]. The equation developed for drying time in term of air temperature and size of green chilli is presented in equation 3.

$T_d = 3.06 – 1.16*Ta + 0.1975*d + 0.0375*Ta*d + 0.5166*Ta^2 + 0.3416*d^2$…………………..(3)

The effect of the two independent variables (T_a, d) on drying time (T_d) predicted from regression model is shown in Fig 1. The responses plot shows that with increase in size (d), there is increase in drying time (T_d). It is clear from Fig. 1 that with increase in drying air temperature, the drying time decreases due to higher rate of drying at enhanced temperature.

Table 3: The data of various drying parameters and their responses

Experiment No.	Air Temperature (°C) Coded and Actual T_a	Size (mm) Coded and Actual d	Drying time (h) T_d	Rehydration ratio (RR)	Visual colour (VC)
1	-1 (53)	-1 (6.5)	5.35	4.8	1.1
2	1(67)	-1 (6.5)	2.86	5.3	1.4
3	-1 (53)	1(13.5)	5.45	5.7	1.45
4	1 (67)	1 (13.5)	3.11	5.9	1.9
5	-1.414 (50)	0 (10)	5.38	5.2	1.34
6	1.414 (70)	0 (10)	2.25	5.6	1.4
7	0 (60)	-1.414 (5)	3.03	5.1	1.5
8	0 (60)	1.414 (15)	3.90	5.9	1.73
9	0 (60)	0 (10)	3.03	5.1	1.5
10	0 (60)	0 (10)	3.08	5.25	1.7
11	0 (60)	0 (10)	3.08	5.27	1.67
12	0 (60)	0 (10)	3.07	5.23	1.7
13	0 (60)	0 (10)	3.06	5.3	1.65

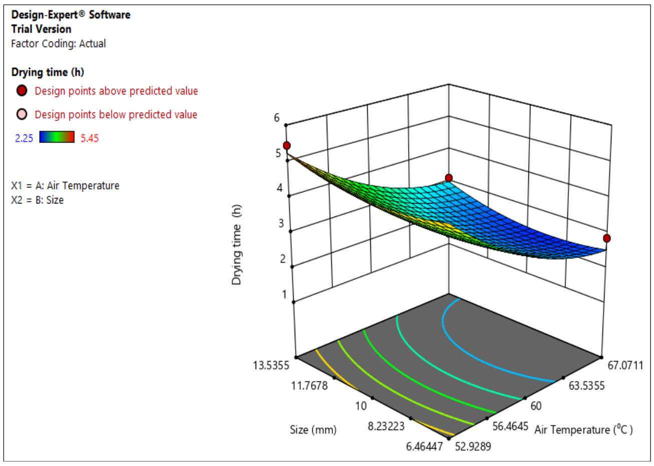

Fig 1: Effect of air temperature and size on drying time

Effect of process parameters on rehydration ratio

The rehydration ratio was found to be in the range of 4.8 to 5.9 for all the dehydrated green chilli. The regression co-efficient were obtained by employing least square technique. The model was tested for its adequacy by analysis of variance and regression equation for rehydration ratio (RR) was found to be highly significant with a coefficient of determination as 0.9809 and F value of 71.84. Similar finding was reported by Raj *et al*. (2013) [8].

The equation developed for rehydration ratio in term of air temperature and size of green chilli is presented in equation 4.

$RR= 5.26 + 0.1582*Ta +0.3289*d – 0.0750*Ta*d+ 0.0638*Ta^2 + 0.1137*d^2$ ………………………. (4)

The effect of independent variables (T_a, d) on rehydration ratio (RR) predicted using regression model is shown in Fig 2. It is clear from Fig. 2 that with increase in size (d), there is increase in rehydration ratio (RR). The rehydration ratio was found to increase slightly with increase in air temperature. This could be due to larger vapour pressure difference. The effect of size on rehydration ratio was found to be more than that the effect of air temperature as evident from high value of F.

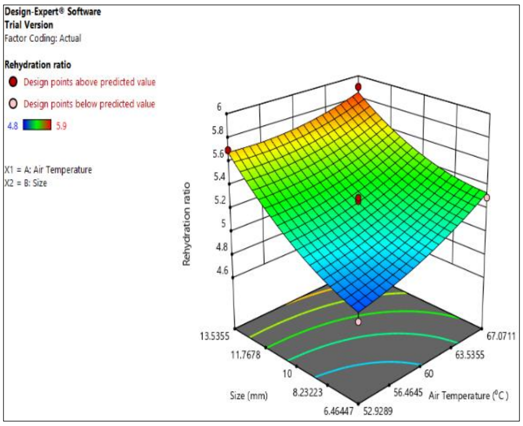

Fig 2: Effect of air temperature and size on rehydration ratio

Effect of process parameters on visual Colour

The regression co-efficient was obtained by employing least square technique and the model was tested for adequacy by analysis of variance. The regression model for visual colour (VC) was found to be significant with a coefficient of determination as 0.7445 and F value of 14.57. Similar finding was reported by Raj *et al.* (2013) [8]. The equation developed for visual colour in term of air temperature and size of green chilli is presented in equation 5.

VC = 1.58 + 0.1751*Ta + 0.1469*d................................ (5)

The effect of independent variables air temperature and size on visual colour (VC) is shown in Fig. 3. With the increase in the value of size, there is increase in visual colour (VC) and but increase was marginal with increase in air temperature.

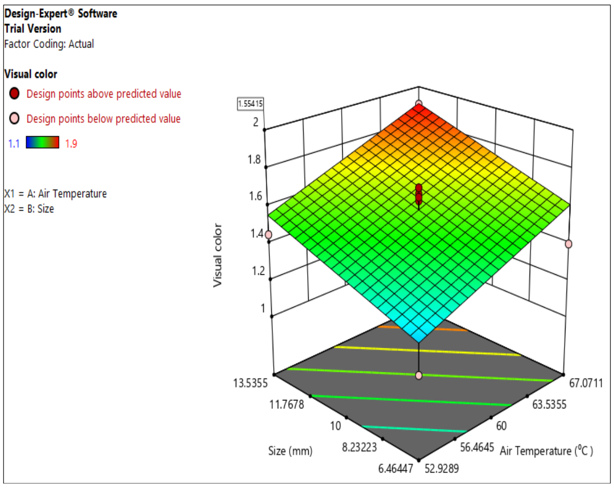

Fig 3: Effect of air temperature and size on visual colour

Optimization of Process Parameters

The numerical optimization technique (Design-Expert software) was used to get the optimum values of the independent variables i.e air temperature and size of green chilli. The response variables selected for optimization were drying time, rehydration ratio and visual colour. The optimum condition was optimized by minimizing drying time, maximizing the rehydration ratio, and minimizing visual colour. The optimum value of drying air temperature and size was found to be 53 ^{o}C and 13.5 mm at desirability value of 0.6. At this optimum condition, the drying time, rehydration ratio and visual colour were found to be 5.23 hours, 5.68 and 1.55 respectively. The optimum values obtained can be used for further drying of green chilli with retention of desired quality attributes.

Conclusion

Dehydration of green chilli is used to extend shelf life with quality attributes. In this study, optimization of operating conditions of dehydration of green chilli was carried out using response surface methodology. The independent variables taken were size of green chilli and hot air temperature while response variables taken were drying time, rehydration ratio and visual color of dehydrated green chilli. Blanched green chilli samples of size (5 mm -15 mm) were dehydrated in a hot air oven at air temperature of 50 ^{0}C - 70 ^{0}C. The optimized value of drying air temperature and size were found to be 53 ^{0}C and 13.5 mm at desirability value of 0.60. At this optimum operating condition, the drying time, value of rehydration ratio and visual colour were found to be 5.23 hours, 5.68 and 1.55 respectively. The optimized dying conditions could be utilized for drying of green chilli by small scale food processing industry

References

1. Bodra Niman, Ansari Md IA. Optimization of Blanching Treatments of Green Chilli, International Journal of Chemical Studies. 2018; 6(6):486-489.
2. Kumar Ravi, Kumar Vivak, Singh GR, Singh BR, Singh Samsher Jaivir, Kumar Cohen S *et al.* Progress in food dehydration. Trends in Food Science & Technology, 1995, 6.
3. Haber A, Runyon R. General Statistics, 3rd Edn. Reading, MA: Addison:- Wesley Publishing Company, 1977.
4. Jasim A, Shivare US. Effect of pretreatment on drying characteristics and colour of dehydrated green chillis. Journal of Food Science and Technology. 2001; 38(5):504-506.
5. Kaleemullah S, Kailappan R. Modelling of thin-layer drying kinetics of red chillies. J Food En. 2006; 76:531-537.
6. Kinsella JE. Functional properties of soy proteins. Journal of American Oil Chemist Society. 1979; 56:242-58.
7. Pushpendra. Drying characteristics of green chillies under different dryer, International Journal of Chemical Studies. 2017; 5(4):407-409.
8. Raj Jyotsna, Ansari Md IA, Rai Pramod, Prasad Gajendra. Optimization of drying conditions of button mushroom (*Agaricus bisporous*). Journal of Research, BAU. 2013; 25(1):36-40.
9. Singh Y, Sharma M, Sharma A. Genetic variation, association of characters and their direct and indirect contributions for improvement in chilli peppers. Int J Veg Sci. 2009; 15(4):340-368.
10. Shanmughavelu KG. Production technology of vegetable crops 2nd edition. Oxford and IBH publishing Co Pvt Ltd, new delhi, India, 1989, 716.
11. Siriwattananon Lalita, Maneerate Jiradech. Effect of drying methods on dietary fiber content in dried fruit and vegetable from non-toxic agricultural field, International Journal of Geomate. 2016; 11(28):2896-2900.
12. Tummala J, Galla NR, Dubasi GR. Physico-chemical changes during processing and storage of green chilli (*Capsicum annuum* L) powder. Journal of Food Processing and Preservation. 2008; 32:868-80.