CHEMICAL PROPERTIES OF FOAM MAT-DRIED TOMATO POWDER AS AFFECTED BY PROCESS VARIABLES

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Abstract
This research aimed at studying the optimization of process variables for the production of quality foam mat-dried tomato. The method of drying used for this study is foam mat drying and oven drying which serves as the control. For this study, Box-Behnken experimental design of response surface methodology (RSM) was used for designing the experiments. The independent variables selected for the foam mat drying were acacia gum (1 - 3 %) as foam stabilizer, temperature (60 -80 °C) and weight of tomato pulp (170, 190 and 210 g/m^2). While for the controls were just dried at different temperature ranges of 60, 70 and 80 °C. The fresh ripe tomato was washed, desked, cut into smaller pieces, pulped before adding the foaming agent and stabilizer then whipped for 7 min and dried in a rectangular tray at 60, 70, 80 °C, scarped, milled and packaged in air tight container. Lycopene, total sugar, ascorbic acid, beta-carotene, and total soluble solids ranged from 2.87 – 11.80 mg/100g, 0.0002 – 0.0012 mml/L, 121.01 – 127.50 mgL-1, 1.40 – 2.47 mg, 4.60 – 7.27°Brix respectively and their controls ranged from 6.79 – 9.26 mg/100g, 0.0001 – 0.0008 mml/L, 60.13- 70.81 mgL-1, 0.56 – 0.83 mg and 0.80 – 1.60°Brix respectively.
Keywords: Foam Mat Dried Tomato Powder; Process Variables; Chemical Properties; Lycopene; Correlation; Optimization; Face Centered Composite Design.
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Introduction

Tomato (Lycopersicon esculentum) is a fruit of high economic value and importance. It is widely consumed in Sub-Saharan Africa, Nigeria inclusive [1] and other parts of the world. [2]. It is an important source of minerals, iron, phosphorus, organic acid, essential amino acids, dietary fibers, beta-carotene pigments, antioxidants such as lycopene, phenolics, and vitamins (A and C) and has been linked with reduced risk of prostate cancer and heart diseases [3], [4], [5]. Tomato is of great economic importance in Nigeria owing to the fact that the production is lucrative and is that business which guarantee good returns on investment because it is being demanded for domestic use and industrial use in Nigeria, and such demand has brought about peak rates for tomato demand. Taking a look into international tomato market, Nigeria has made relatively contribution to the global supplies, which have actually earned the country's foreign exchange which is likely to stimulate national food sufficiency if more attention is given to tomato production in Nigeria.

Drying has been known to be economical food processing technique and is gaining popularity in Nigeria [6]. Drying techniques include freeze drying, foam-mat drying, vacuum drying, solar drying, and spray drying etc. Among all these foam-mat drying is considered to be advantageous in terms of drying of the foams at lower temperature compared with other methods of drying non-foamed materials in the same dryer type [7]. Foam mat drying is regarded as one of the very effective methods where removal of moisture takes place from the fruit pulps to obtain a free-flowing powder that has good reconstitution characteristics [8]. It was developed by [9] as a process whereby liquid or semi liquid food is converted to form stable foam by cooperation with foaming agents or stabilizing agents. The foam is then spread into a thin sheet and dried by using hot air at lower temperature compare to other drying techniques. Foam mat drying technique is mostly use for heat sensitive, sticky, viscous and high sugar content food products. Foam-mat drying technology has been applied on many fruits and vegetables in recent years. Among these includes tomatoes [10], Papaya [11], mango [12], cowpea [13] etc.

Foam mat dried powder is rich in biochemical composition than non-foam dried powder. Powder from foam-mat drying is almost similar to the fresh sample in color, flavor and in taste [14]. Egg albumin is used as foaming agent because it induces and increases foam from 6 to 8 times the volume. Acacia Gum is used as foam stabilizer because its acts as thickening agents, binders, emulsifiers, stabilizers, suspension aids, reduces thickness of powder and produces a non- sticky, free flowing powder. To obtain stable foam, it is important to optimize the various process condition by selecting appropriate concentration of foaming agent, foam stabilizer, pulp concentration etc. The concentration of the foam stabilizer should be optimized as below the critical concentration in which the foam is unstable, whereas overdose stabilizer can result in foam collapse [15]. The optimization process parameter can be done by various techniques, one of the effective methods and commonly used techniques for this purpose is response surface methodology. RSM has been demonstrated to be a powerful tool for determining the factors and their interactions, which allow process optimization to be, conducted effectively [16]. The method is the preferred experimental design for fitting polynomial model to analyze the response surface of multi factor combinations and a faster and more economical method for gathering research results classic one variable at a time or full factors experimentation [17]. The main advantage of this RSM is the reduced number of experimental trials needed to evaluate multiple parameters and their interactions, therefore, it is less laborious and time-consuming than other approaches required to optimize a process.

This research work is aimed at studying the optimization of process variables (Concentration of Foam Stabilizer, drying temperature and weight of pulp) for the production of quality foam mat-dried tomato powder.

Materials and Methods

Source of Materials

Fresh ripe tomatoes and egg white powder were purchased from Eke-Awka Market, Anambra State Nigeria. Acacia gum of CAS No.9004-32-4 (food grade) was bought from Altran Chemical Store Nsukka – Nigeria. Other materials that were used include oven, conical flask of various types, blender (Master chef MC-307B), digital weighing balance (AR3130), stainless steel tray and containers.

Preparation of the Sample

Sample preparation and production of foam mat dried tomato powder was carried out in the food processing laboratory at the department of food science and technology Nnamdi Azikwe University, Awka, Anambra State while the analysis was conducted in their food analysis Laboratory. Tomato was washed with running tap water to remove unwanted external material such as dust, clay etc. Then, were cut with a stainless-steel knife and passed through a Blender (ORPAT model: HHB 100E, Ajanta Limited, Morbi, India) to make tomato Pulp. Eggs weighing between 47.2 and 50.7 g which contains about 26.7 to 28.5 g of egg albumin was added. The egg albumin extract was homogenized for 2 min and used as foaming agent. Foaming was achieved by adding foaming agent at a constant value of 14g and foam stabilizer in different concentrations at a whipper. Different quantities of tomato pulp were measured, along with the selected concentrations of foam stabilizer and egg albumin which is constant at 14g. Then the mixers were whipped using hand blender (ORPAT model: HHB 100E, Ajanta Limited, Morbi, India) at a constant time of 7min.

The foamed tomato pulp was poured in a tray (stainless steel) and placed in an oven dryer (Model: SFKM9051D, 220-240V ~ 50- 60Hz 1000W) at different temperature rates for drying the different samples. After drying, the dried tomato pulp was ground and sieved to form powder. The reconstitution of powder was done by the method of [18] with few alternations. For reconstitution, 2 g of powder was mixed with 50 mL distilled water in a 100 mL glass beaker at room temperature and the mixture was agitated with the vortex at high speed. The reconstituted sample was used to determine the amount of TSS, pH, titratable acidity, ascorbic acid, beta carotene.

Experimental Design

The central composite face-centered design (CCFC) was used in this work using Design Expert software version 12. Table 1 shows the process variables and their levels. The experimental matrix that was used in this study, based on central composite face-centered design is as shown in table 2. The experimental space had a total of 20 runs. The data obtained from the study was fitted to the second-order polynomial regression model [19] of the form:

$$Y = b_0 + b_1A + b_2B + b_3C + b_{11}A^2 + b_{22}B^2 + b_{33}C^2 + b_{12}AB + b_{13}AC + b_{23}BC + e \qquad (1)$$

Where Y = Response Parameters

b_0 = *intercept*

b_1-b_{23} = *Coefficient estimate of the linear, interaction and square terms*

A = Concentration of foam stabilizer (%)

B = Temperature of drying (°C)

C = Weight of tomato pulp (g/m²)

e = Estimated Error

Analysis

Total Sugar

Estimation of total sugars was done using a phenol-sulphuric acid method by [20]. A reconstituted sample was appropriately diluted, from which 0.1 ml was further diluted to 1 ml with distilled water. To this, 0.5 ml of 5% phenol was added followed by the addition of 5 ml of H_2SO_4 after 10 min. Test tubes was incubated at 37◦C for 30 min and absorbance was read at 490 nm against reagent blank on an UV visible spectrophotometer (Elico SL-164, Elico Ltd., Hyderabad, Andhra Pradesh, India). The percentage of total carbohydrates was worked out from the standard curve of glucose and calculated as:

$$\text{Total Sugar (\%)} = \frac{\text{Sugar value from the graph (μg)} \times \text{total volume of extract (ml)}}{\text{Aliquot of the sample used (ml)} \times \text{Volume of sample} \times 1000} \quad (2)$$

Ascorbic Acid (Vitamin C)

Ascorbic acid content in reconstituted foam mat dried tomato powder was determined by following the method of [21]. About 5 mL sample was taken and made up to 50 mL with 3% HPO_3. After that filtration was done using Whatman No. 2 filter paper. Approximately, 10 mL of filtrate was taken with 10 mL HPO_3 titrate it with the 2,6 dichlorophenolindophenol until it turned into pink color endpoints and the color persists in the solution for almost 15 s. Dye factor in mg of ascorbic acid per mL of the dye factor was calculated by using the following formula: Dye factor = 0.5/titre

$$= \frac{\text{Titer} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{Weight or volume of sample taken for estimation}} \quad (3)$$

Table 1: Key depicting independent variables and their levels.

Parameters	**Levels of the factors**		
	-1	**0**	**+1**
Foaming Agent (%) A	1	2	3
Temperature (°C) B	60	70	80
Weight of Pulp(g/m^2) C	170	190	210

Table 2: Face Centered Central Composite Design (FCCCD) matrix and the independent variables and their actual levels and coded values.

	Factor 1	Factor 2	Factor 3
Samples	A: Acacia Gum (%)	B: Temperature (^oC)	C: Weight of tomato pulp (g/m^2)
1	2 (0)	70 (0)	210 (+1)
2	2 (0)	70 (0)	190 (0)
3	1 (-1)	60 (-1)	170 (-1)
4	1 (-1)	60 (-1)	210 (+1)
5	2 (0)	80 (+1)	190 (0)
6	1 (-1)	80 (+1)	170 (-1)
7	3 (+1)	70 (0)	190 (0)
8	3 (+1)	60 (-1)	170 (-1)
9	2 (0)	70 (0)	170 (-1)
10	2 (0)	60 (-1)	190 (0)
11	2 (0)	70 (0)	190 (0)
12	2 (0)	70 (0)	190 (0)
13	1 (-1)	80 (+1)	210 (+1)
14	2 (0)	70 (0)	190 (0)
15	2 (0)	70 (0)	190 (0)
16	3 (+1)	60 (+1)	210 (+1)
17	1 (-1)	70 (0)	190 (0)
18	3 (+1)	80 (+1)	170 (-1)
19	3 (+1)	80 (+1)	210 (+1)
20	2 (0)	70 (0)	190 (0)
21 (Control)	-	60 (-1)	-
22 (Control)	-	70 (0)	-
23 (Control)	-	80 (+1)	-

Values in bracket are the coded values while the ones not in bracket are the actual values

Titratable Acidity Determination

The titratable acidity of the plum juice/reconstituted sample was estimated by adopting the method of [22]. A small portion of the powder sample was reconstituted in a beaker with water to a set 10 mL volume. The sample solution was then titrated with 0.1 M NaOH and 2 drops of phenolphthalein as an indicator. Equations (3) and (4) were used to compute the % acidity as anhydrous citric acid.

$$= \frac{0.1\text{ M NaoH x volume of NaoH (In litre)}x\ 192.43}{3} \quad (4)$$

$$= \frac{\text{weight of citric acid}}{\text{weight of sample aliquot}}\ x\ 100 \quad (5)$$

pH Determination

The pH of the samples was measured using a digital pH meter (Model Hanna pH 211, Sigma-Aldrich) following the method adopted by [23]. The pH electrode was washed with phosphate buffer solutions (pH = 7:2) after each measurement

Lycopene Determination

Lycopene was determined, using the method of [22], with some modification. Briefly, dry tomato powder (500 mg) was homogenized and agitated with 5 ml of petroleum ether, allowed to settle down, and then supernatant was decanted. The procedure was repeated until no color is obtained and supernatants was pooled and final volume was made up to 10 ml. The absorption of the supernatant was recorded at 505 nm on UV visible spectrophotometer. Lycopene content was calculated as follows:

$$\text{Lycopene (mg/100)} = \frac{3.1206 \times \text{Final volume} \times \text{Optical density} \times 100}{\text{Weight of sample taken (gm)} \times 1000} \quad (6)$$

Total Soluble Solids (TSS) Determination

The TSS was estimated in brix scale using a hand refractometer (Model Atago 2353, MASTER-53M) following the method of [23]. Briefly, 1–2 drops of reconstituted sample juice were taken into the glass prism of the refractometer and covered with its plate and reading was taken in face of light.

Beta-carotene content Determination

The β-Carotene of reconstituted foam mat dried tomato powder was determined according to the method of [24]. In a test tube, 1 g of reconstituted tomato pulp was added with 5 mL chilled acetone. Then it was shaking occasionally for 15 min. Then it was vortexed in a vortex (Model-VM2000, Taiwan) for 15 min at high speed. Then it was centrifuged for 10 mins with a centrifuge (Model-416G, Gyrozen, Korea) at 1370 rpm. The supernatant was separated in a test tube. Again, this process was run once more with the remaining compounds with the addition of 5 mL chilled acetone. The supernatant was then filtered with a Whatman No. 1 filter paper. Then, 0.025 g of standard β-Carotene was mixed with 5 mL acetone and kept in a dark place for 10 min. The absorbance of extract and standard solution of β-Carotene were measured by using UV-V is spectrophotometer at 449 nm wavelength (Model-1800, Shimadzu).

$$Wt\ of\ \beta\left(\frac{mg}{100g}\right) - Carotene =$$

$$\frac{\text{Weight of Beta carotene}}{\text{Absorbance of beta carotene}}\ X\ Absorbance\ of\ sampleX\ 1000 \quad (7)$$

Statistical Design and Analysis

All Analysis was carried out in triplicate determinations The data obtained from the study was analyzed using analysis of variance (ANOVA) which was carried out using SPSS Software Version 27. The ANOVA was used to determine the statistical significance in the processing variables (Concentration of foam stabilizer, weight of pulp and drying temperature) on the response variables (Physico-chemical Properties) of the foam mat dried tomato powder.

Plate 1: Fresh Tomato

Plate 2: Foam Mat Tomato Pulp

Plate 3: Foam Mat Dried Tomato Powder

Results and Discussion

This research was designed to evaluate the effect of process variables (Concentration of foam stabilizer, temperature of drying and weight of tomato pulp) on the physicochemical properties of foam mat dried tomato powder using response surface approach.

The result in Table 3 shows the Titratable Acidity, pH, Lycopene, Total Sugar, Ascorbic Acid, Total Soluble Solids and Beta-carotene of the tomato powder. The Ideal regression equation showing the response variables as a function of the independent (Process Variables) is presented in equation 8

$$Y = b_0 + b_1A + b_2B + b_3C + b_{11}A^2 + b_{22}B^2 + b_{33}C^2 + b_{12}AB + b_{13}AC + b_{23}BC + e \quad (8)$$

Titratable Acidity

Table 3 shows that the titratable acidity (TA) of reconstituted foam mats dried tomato powder ranges from 0.98-2.48 % as compared to the control which ranges from 0.90 – 1.96 %. Where sample 8 had the lowest TA and sample 13 had the highest TA. Data presented in Table 3 shows that there was a decrease in titratable acidity of the powder. Statistically, weight of the pulp had significant effect ($p < 0.01$) on the TA of the samples while foam stabilizer did not make any significant ($p < 0.05$) effect on titratable acidity of the foam mat dried tomato powder.

However, the results were higher than the one recorded by [25]. They observed a decrease of 0.39 to 0.37 % where they concluded that with the increase of foaming agent concentration and temperature affected the titratable acidity of the reconstituted powder.

$$TA = 1.85 - 0.1658A - 0.00344B + 0.3113C \quad (9)$$

The mathematical model for the titratable acidity of the tomato powder was presented in Eq.9 while Figure 1 shows its contour. An increase in concentration of foam stabilizer and temperature of drying caused an increase in the TA content of the tomato pulp. However, increase in weight of tomato pulp increased the titratable acidity of the foam mat dried tomato powder because weight of pulp showed a positive coefficient. Concentration of foam stabilizer caused a greater decrease in TA because the coefficient of the foam stabilizer (-0.1658) is larger than that of the drying temperature (-0.00344).

Table 3 Chemical Composition of Foam Mat Dried Tomato Powder

Sample	Process Variables			Titratable Acidity	pH	Lycopene	Total Sugar	Ascorbic Acid	Beta-Carotene	TSS
	%	^oC	g/m^2							
1	2	70	210	$1.89^{j} \pm 0.00$	$5.05^{h} \pm 0.01$	$9.40^{l} \pm 0.00$	$0.0005^{abc} \pm 0.00$	$123.18^{ab} \pm 2.68$	$1.49^{hi} \pm 0.00$	$6.25^{a} \pm 0.07$
2	2	70	190	$2.08^{mno} \pm 0.02$	$4.84^{cd} \pm 0.00$	$10.95^{l} \pm 0.08$	$0.0008^{abcd} \pm 0.00$	$122.03^{ab} \pm 4.21$	$1.40^{g} \pm 0.04$	$5.00^{f} \pm 0.00$
3	1	60	170	$1.62^{f} \pm 0.02$	$4.67^{b} \pm 0.03$	$11.80^{n} \pm 0.06$	$0.0002^{ab} \pm 0.00$	$125.00^{ab} \pm 0.00$	$1.67^{k} \pm 0.04$	$4.60^{d} \pm 0.00$
4	1	60	210	2.21 ± 0.00	$4.58^{a} \pm 0.00$	$3.67^{c} \pm 0.00$	$0.0002^{abcd} \pm 0.00$	$127.50^{ab} \pm 3.54$	$1.30^{e} \pm 0.01$	$4.80^{e} \pm 0.14$
5	2	80	190	$1.42^{d} \pm 0.00$	$5.56^{i} \pm 0.05$	$5.31^{d} \pm 0.01$	$0.0009^{ab} \pm 0.00$	$124.92^{b} \pm 0.00$	$1.51^{i} \pm 0.01$	$6.30^{m} \pm 0.00$
6	1	80	170	$1.55^{e} \pm 0.00$	$4.95^{fg} \pm 0.01$	$8.27^{k} \pm 0.03$	$0.0004^{abc} \pm 0.00$	$124.98^{ab} \pm 0.00$	$1.74^{l} \pm 0.01$	$7.00^{o} \pm 0.00$
7	3	70	190	$2.03^{l} \pm 0.00$	$4.86^{cde} \pm 0.04$	$6.85^{g} \pm 0.00$	$0.0011^{cd} \pm 0.00$	$123.20^{ab} \pm 2.60$	$1.84^{n} \pm 0.01$	$6.51^{n} \pm 0.01$
8	3	60	170	$0.98^{b} \pm 0.00$	$5.04^{h} \pm 0.05$	$3.40^{b} \pm 0.06$	$0.0002^{a} \pm 0.00$	$121.01^{c} \pm 0.00$	$2.12^{p} \pm 0.00$	$4.70^{de} \pm 0.01$
9	2	70	170	$1.84^{i} \pm 0.00$	$4.92^{efg} \pm 0.00$	$7.72^{h} \pm 0.12$	$0.0002a \pm 0.00$	$125.02^{ab} \pm 0.00$	$1.48^{hi} \pm 0.04$	$5.41^{jk} \pm 0.14$
10	2	60	190	$1.80^{h} \pm 0.01$	$4.94^{fg} \pm 0.06$	$6.68^{fg} \pm 0.21$	$0.0004^{abc} \pm 0.00$	$121.32^{c} \pm 5.20$	$1.91^{o} \pm 0.03$	$5.41^{jk} \pm 0.00$
11	2	70	190	$2.04^{lm} \pm 0.01$	$4.81^{c} \pm 0.00$	$10.91^{l} \pm 0.00$	$0.0008^{abcd} \pm 0.00$	$122.48^{ab} \pm 0.00$	$1.42^{fg} \pm 0.00$	$5.24^{hi} \pm 0.01$
12	2	70	190	$2.08^{no} \pm 0.03$	$4.95^{fg} \pm 0.04$	$11.03^{lm} \pm 0.00$	$0.0012^{cd} \pm 0.00$	$122.60^{ab} \pm 0.01$	$1.12^{d} \pm 0.00$	$5.51^{k} \pm 0.01$
13	1	80	210	$2.49^{q} \pm 0.00$	$5.07^{h} \pm 0.03$	$6.59^{f} \pm 0.07$	$0.0002^{a} \pm 0.00$	$125.01^{ab} \pm 0.01$	$1.59^{j} \pm 0.01$	$5.86^{m} \pm 0.08$
14	2	70	190	$2.11^{o} \pm 0.00$	$4.93^{fg} \pm 0.04$	$10.91^{l} \pm 0.00$	$0.0008^{abcd} \pm 0.00$	$122.03^{ab} \pm 4.21$	$1.45^{gh} \pm 0.00$	$5.72^{l} \pm 0.01$
15	2	70	190	$2.08^{no} \pm 0.06$	$4.83^{cd} \pm 0.01$	$11.14^{m} \pm 0.00$	$0.0009^{abcd} \pm 0.00$	$122.04^{ab} \pm 4.21$	$1.34^{f} \pm 0.00$	$5.12^{g} \pm 0.01$
16	3	60	210	$2.07^{mno} \pm 0.00$	$4.97^{g} \pm 0.01$	$6.38^{e} \pm 0.00$	$0.0004^{abc} \pm 0.00$	$125.00^{ab} \pm 0.00$	$2.47^{q} \pm 0.00$	$5.41^{jk} \pm 0.01$
17	1	70	190	$1.73^{g} \pm 000$	$4.57^{a} \pm 0.02$	$8.00^{i} \pm 0.00$	$0.0003^{abc} \pm 0.00$	$125.02^{ab} \pm 0.00$	$1.80^{mn} \pm 0.05$	$5.20^{gh} \pm 0.00$
18	3	80	170	$1.21^{c} \pm 0.00$	$5.06^{h} \pm 0.00$	$5.24^{d} \pm 0.00$	$0.0005^{abc} \pm 0.00$	$125.16^{ab} \pm 0.01$	$1.79^{m} \pm 0.02$	$7.21^{p} \pm 0.01$
19	3	80	210	$1.66^{f} \pm 0.00$	$5.56^{i} \pm 0.07$	$2.87^{a} \pm 0.02$	$0.0004^{abc} \pm 0.00$	$125.00^{ab} \pm 0.00$	$1.45^{gh} \pm 0.00$	$6.22^{m} \pm 0.01$
20	2	70	190	$2.05^{lmn} \pm 0.01$	$4.89^{def} \pm 0.01$	$10.87^{l} \pm 0.00$	$0.0011^{bcd} \pm 0.00$	$122.03^{ab} \pm 4.21$	$1.40^{g} \pm 0.00$	$5.34^{ij} \pm 0.01$
21 (60^oC)	-	60	-	$0.90^{a} \pm 0.00$	$4.67^{b} \pm 0.01$	$6.79^{g} \pm 0.00$	$0.0003^{d} \pm 0.00$	$70.81^{b} \pm 0.00$	$0.83^{c} \pm 0.00$	$0.80^{a} \pm 0.01$
22 (70^oC)	-	70	-	$3.67^{r} \pm 0.00$	$4.79^{c} \pm 0.01$	$8.20^{j} \pm 0.00$	$0.0008^{abcd} \pm 0.00$	$69.43^{b} \pm 0.00$	$0.64^{b} \pm 0.00$	$1.35^{b} \pm 0.07$
23 (80^oC)	-	80	-	$1.96^{k} \pm 0.04$	$4.55^{a} \pm 0.00$	$9.26^{l} \pm 0.04$	$0.0001^{a} \pm 0.00$	$60.13^{a} \pm 0.00$	$0.56^{a} \pm 0.00$	$1.60^{c} \pm 0.00$

Values are means of duplicate determinations ± Standard Deviation. Values in the same column bearing different superscript differ significantly ($P<0.05$). 21, 22, 23 = Control Sample, Process Variable Combination – Acacia gum (%), Temperature (^oC), Weight of tomato pulp(g/m^2)

Table 4: Summary of Anova and Coefficient Estimate of the chemical composition of the foam mat dried tomato powder for the terms that showed significant model.

Term	Coefficent	pH	Total Sugar	β – Carotene	Total Soluble Solids	TA	Lycopene	Ascorbic Acid
n Intercept	b_0	4.91	0.0009	1.43	5.64	1.85	10.10	122.51
(A)	b_1	0.1640	0.0001	0.1530	0.2590	-0.1658	-1.36	-0.8140
(B)	b_2	0.2010	0.0001	-0.1360	0.7670	-0.0344	-0.3636	0.5240
(C)	b_3	0.0595	0.0000	-0.0540	-0.0380	0.3113	-0.7538	0.4520
(AB)	b_{12}	-0.0194	0.0000	-0.2088	-	-	-0.1330	0.8325
(AC)	b_{13}	0.0506	0.0000	0.0612	-	-	1.30	0.1625
(BC)	b_{23}	0.0969	-0.0001	-0.0537	-	-	0.1385	-0.8275
(A^2)	b_{11}^2	-0.2400	-0.0001	0.2691	-	-	-1.37	1.15
(B^2)	b_{22}^2	0.3000	-0.0001	0.1541	-	-	-2.80	0.1568
(C^2)	b_{33}^2	0.0325	-0.0004	-0.0659	-	-	-0.2302	1.14
R^2 adj		0.8682	0.5412	0.6197	0.5742	0.4190	0.5045	0.6208
% CV		1.85	40.25	11.75	8.49	14.85	25.72	0.836

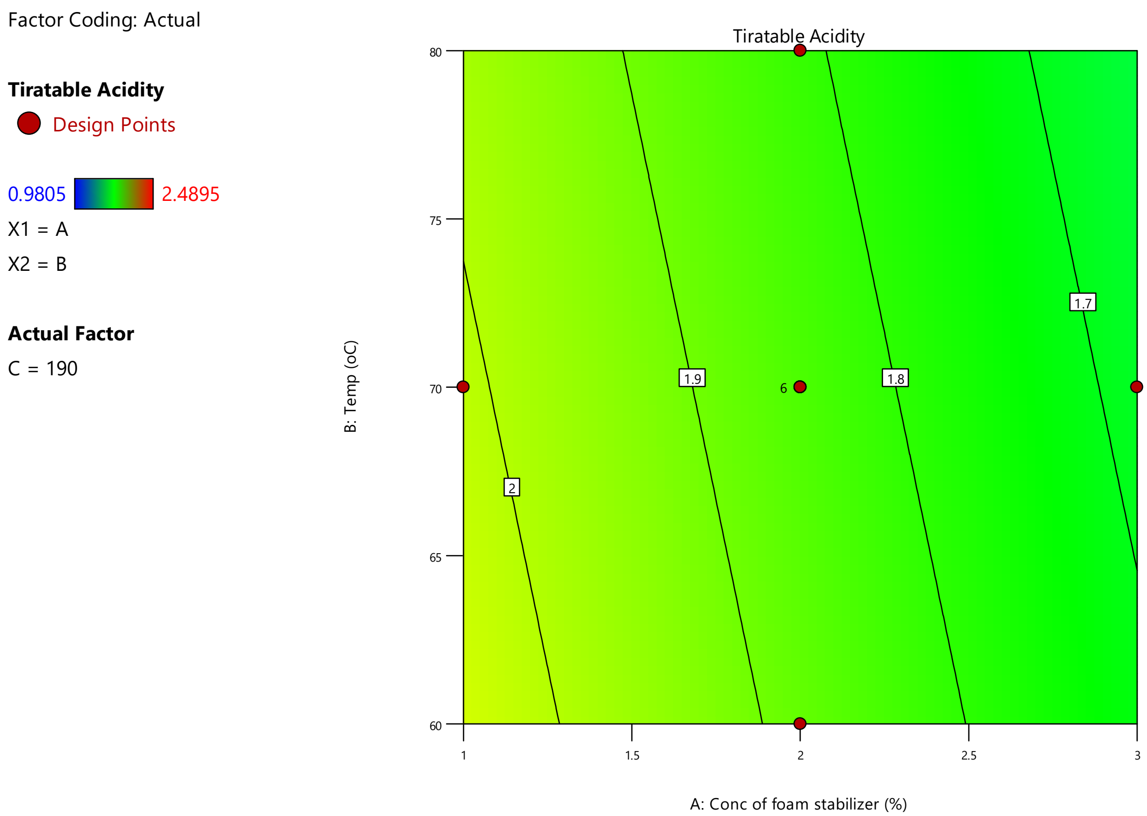

Fig 1: Contour showing interaction effect of concentration of foam stabilizer and temperature on titratable acidity of foam mat dried tomato powder.

Figure 1 shows that the interaction effect of temperature and concentration of foam stabilizer on TA. As the concentration of foam stabilizer increased from 1.3 – 1.88 % and the drying temperature increased from 73 – 80 ºC, the titratable acidity of the tomato powder produced decreased from 2– 1.9 %.

pH

The pH of a product is usually inversely related to drying temperature. The pH of the oven dried reconstituted tomato powder was found to be 4.67, 4.79, 4.55 at 60 ºC, 70 ºC, 80 ºC respectively and in reconstituted foam mat dried tomato powder the pH ranges from 4.56 to 5.56. Sample 17 had the lowest pH and sample 5 had the highest pH. Statistically the foam stabilizer and temperature had significant effect ($p<0.05$) on the pH of the reconstituted samples. A rise in temperature raised molecular vibrations and a reducing aptitude of forming hydrogen bonds raises [H+], which reduces the pH in the reconstituted powder. The result obtained here were quite similar to that obtained by [26] whose result stated an increase in pH from 4.13 to 4.76. They stated that the pH showed an increasing trend with the increasing concentration levels of foaming agents. pH is an important factor in determining the keeping quality of food products. A low pH can inhibit the growth of spoilage microorganisms, while a high pH can promote their growth. Therefore, controlling the pH of a food product is important for maintaining its quality and shelf life [27].

$$pH = 4.91 + 0.1640A + 0.2010B + 0.0059C + 0.0194AB + 0.00506AC + 0.0969BC - 0.2400A^2 + 0.3000B^2 + 0.0325C^2 \quad (10)$$

The mathematical model for the pH of the tomato powder is presented in Eq. 10, while Figures 2, 3 and 4 show its contours. Increasing the concentration of the foam stabilizer, temperature of drying and weight of tomato pulp increased the pH of the tomato powder. Temperature caused greater increase in pH than the other process variables because the coefficient of temperature (0.2010) is higher than that of the concentration of the foam stabilizer (0.1640) and weight of tomato pulp. The interaction of concentration of foam stabilizer and drying temperature, concentration of foam stabilizer and weight of tomato pulp, temperature and weight of tomato pulp showed positive coefficients suggesting an increase in pH of the tomato powder. Squares of B and C would increase the pH whereas that of A would decrease the pH value of the tomato powder.

From Table 4, the C.V is 1.85. CV stands for coefficient of variation, and it is a way to measure the relative variability of a set of data. CV is calculated as the ratio of the standard deviation to the mean, multiplied by 100. A CV of 1.8 means that the standard deviation of the data is 1.8 times the mean. It is a way of expressing the degree of variation of a set of data. A CV of 1.8 indicates a relatively low degree of variability. This means that the majority of the data points are relatively close to the mean and there are not many outliers. It is an indicator of the homogeneity of the data.

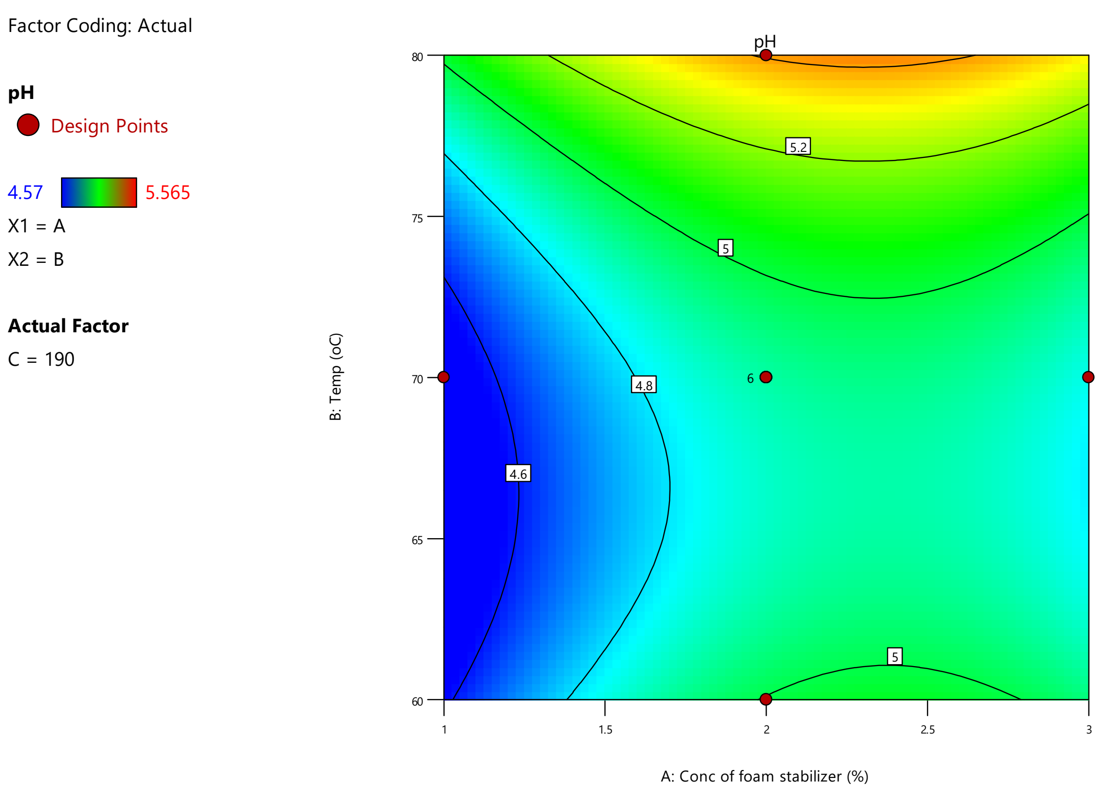

Fig.2: Contour of interaction effect of temperature and concentration of foam stabilizer on the pH of the tomato powder.

Figure 2 shows that as the concentration of foam stabilizer increased from 1.02 – 1.38 % and the drying temperature increased from 73 – 76 °C, the pH of the tomato powder produced increased from 4.6 – 4.8.

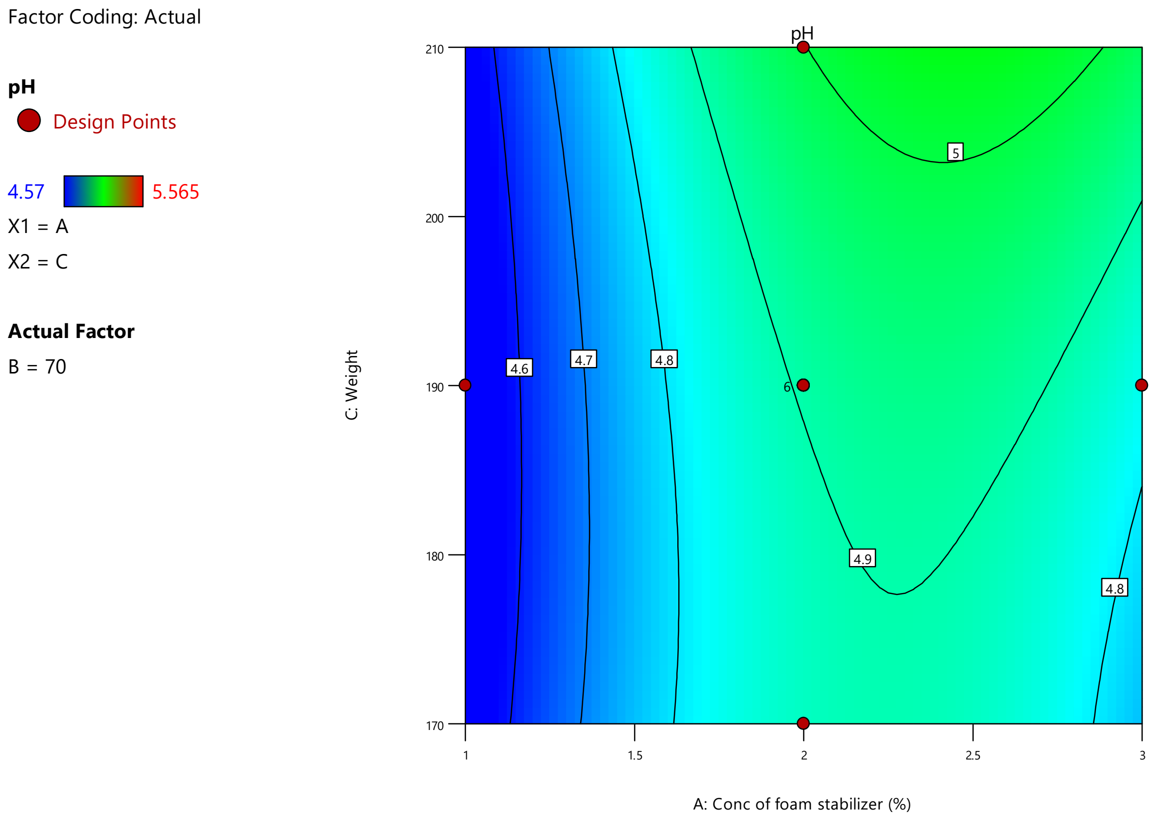

Fig.3: Contour of interaction effect of weight of tomato pulp and concentration of foam stabilizer on the pH of the tomato powder.

Figure 3 shows that as the foam stabilizer increased from 1.13 – 2.05 % and the weight of tomato pulp increased from 184 – 210 g/m^2, the pH of the tomato powder produced increased from 4.6 – 4.8.

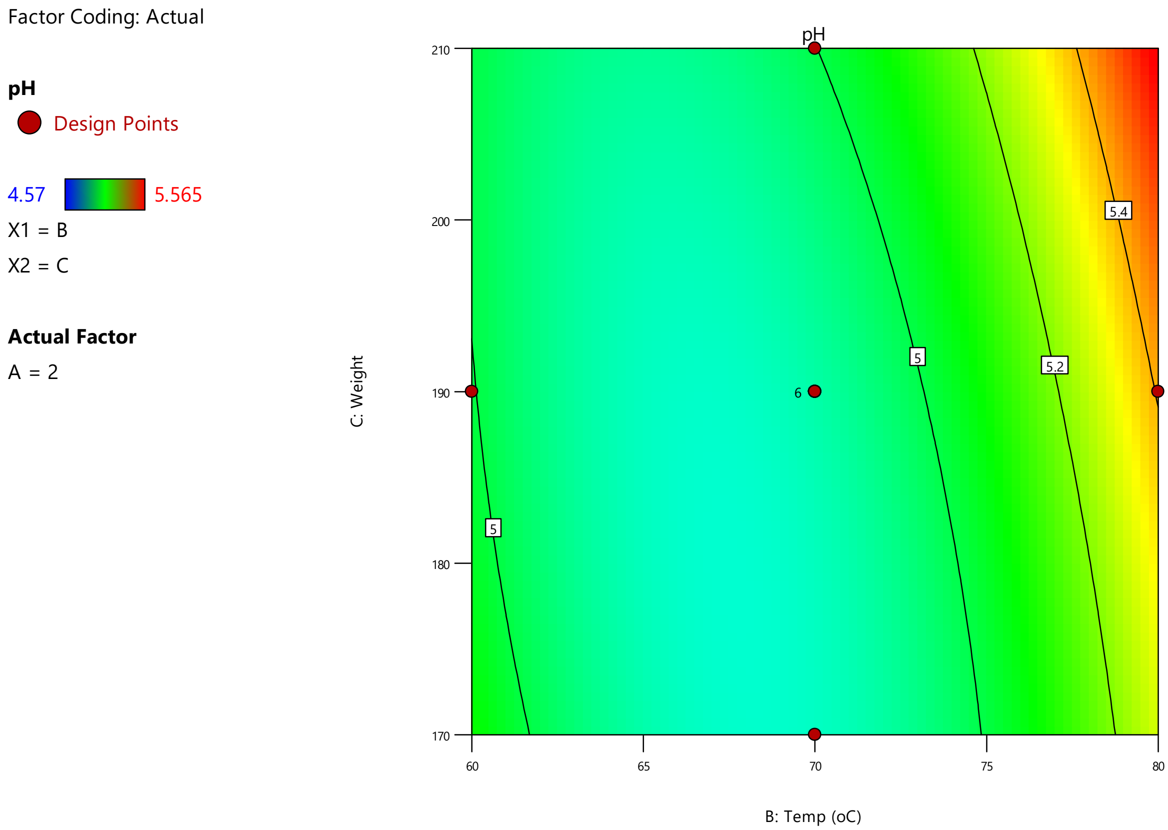

Fig 4: Contour of interaction effect of weight of tomato pulp and temperature on the pH of the tomato powder.

Figure 4 shows that as the temperature increased from 60 - 77 ºC and the weight of tomato pulp increased from 190 - 210 g/m^2, the pH of the tomato powder produced increased from 5 – 5.4.

After running the prediction of actual and predicted values, it was observed that there was a strong positive relationship between the actual and predicted values of pH. This was reflected in a Pearson correlation coefficient of 0.971. This high coefficient indicates that as the actual values of pH increase, the predicted values also tend to increase. This strong correlation suggests that the model used for generating the predicted values is a good fit for the data

Lycopene

Lycopene content of the samples varied from 3.39 to 11.80 mg/100 g. where sample 8 (3% foam stabilizer, 170 weight of pulp at 60 ºC drying temperature) had the lowest lycopene content and sample 3 (1% foam stabilizer, 170 g/m^2 weight of pulp at 60º C temperature) hasd the highest lycopene content. The Lycopene differed significantly from each other ($p<0.05$). However, there was no significant ($p >0.05$) variation with respect to the process variables. There was a decrease in the lycopene content of the foam mat dried tomato powder when compared with the dried tomato powder whose values are 6.78, 8.20, 9.26 mg/100 g at 60 ºC, 70 ºC, and 80 ºC respectively. A similar decrease in lycopene content was reported by [28] in tomato processing from 10.7 to 11.2

mg/100g (mg/100g DW) with an average value of 10.9 mg/100g DW. Also [29] recorded a range of 7.3 to 8.7 mg/100g (mg/100g DW) with an average value of 8.2 mg/100g DW. Lycopene is a powerful antioxidant with many health benefits, including protection from damage caused by radiation, improved heart health and a lower risk of certain types of cancer. It also affects blood sugar levels in individuals respectively.

$$Lycopene = 10.10 - 1.36A - 0.3636B - 0.7538C - 0.1330AB + 1.30AC + 0.1385BC - 1.37A^2 - 2.80B^2 - 0.2302C^2 \quad (11)$$

The mathematical model for the lycopene content of the tomato powder is presented in Eq. 11, while Figures 5, 6 and 7 show its contours. Increasing the concentration of the foam stabilizer, temperature of drying and weight of tomato pulp decreased the lycopene content of the tomato powder. Foam stabilizer caused greater decrease in lycopene content than the other process variables because the coefficient of the foam stabilizer (-1.36) was higher than that of the temperature (-0.3636) and weight of pulp (-0.7538). The interaction of concentration of foam stabilizer and drying temperature (AB) also showed negative coefficient (-0.1330) suggesting that it has a decreasing effect on lycopene content of the powder. Contrarily, the interaction of foam stabilizer and weight of tomato pulp (AC), temperature and weight of tomato pulp showed positive coefficient, suggesting an increase on lycopene content of the tomato pulp. Squares of A, B and C would decrease the lycopene content of the tomato powder.

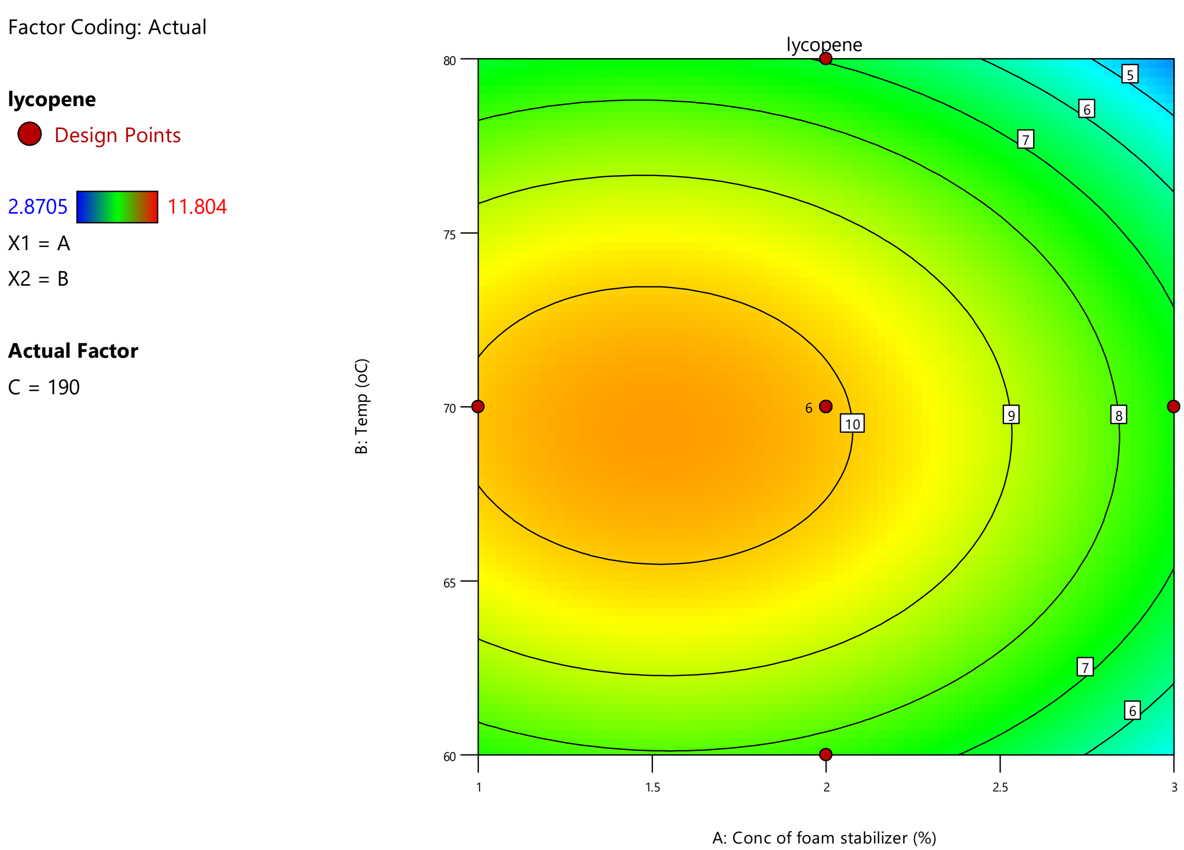

Fig 5: Contour showing the interaction effect of temperature and concentration of foam stabilizer on lycopene content of tomato powder

Figure 5 shows that as the concentration of foam stabilizer increased from 2.0 – 2.76 % and the drying temperature increased from 73 – 78 °C, the lycopene content of the tomato powder decreased from 7 -5 %.

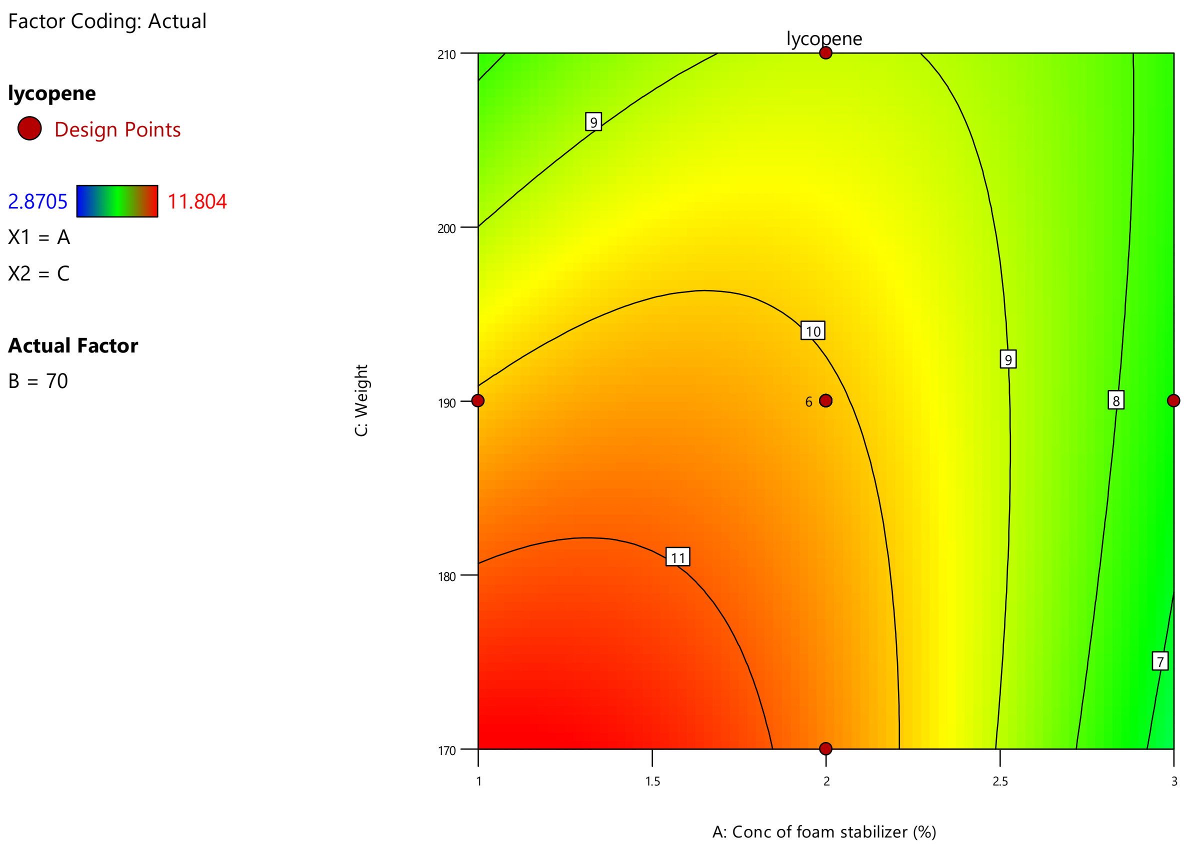

Fig 6: Contour showing the interaction effect of weight of tomato pulp and concentration of foam stabilizer on lycopene content of tomato powder

Figure 6 shows that as foam stabilizer increased from 1.83 – 2.20 % and the weight of tomato pulp increased from 180 – 191 g/m^2, the lycopene content of the tomato powder decreased from 10 – 11 %.

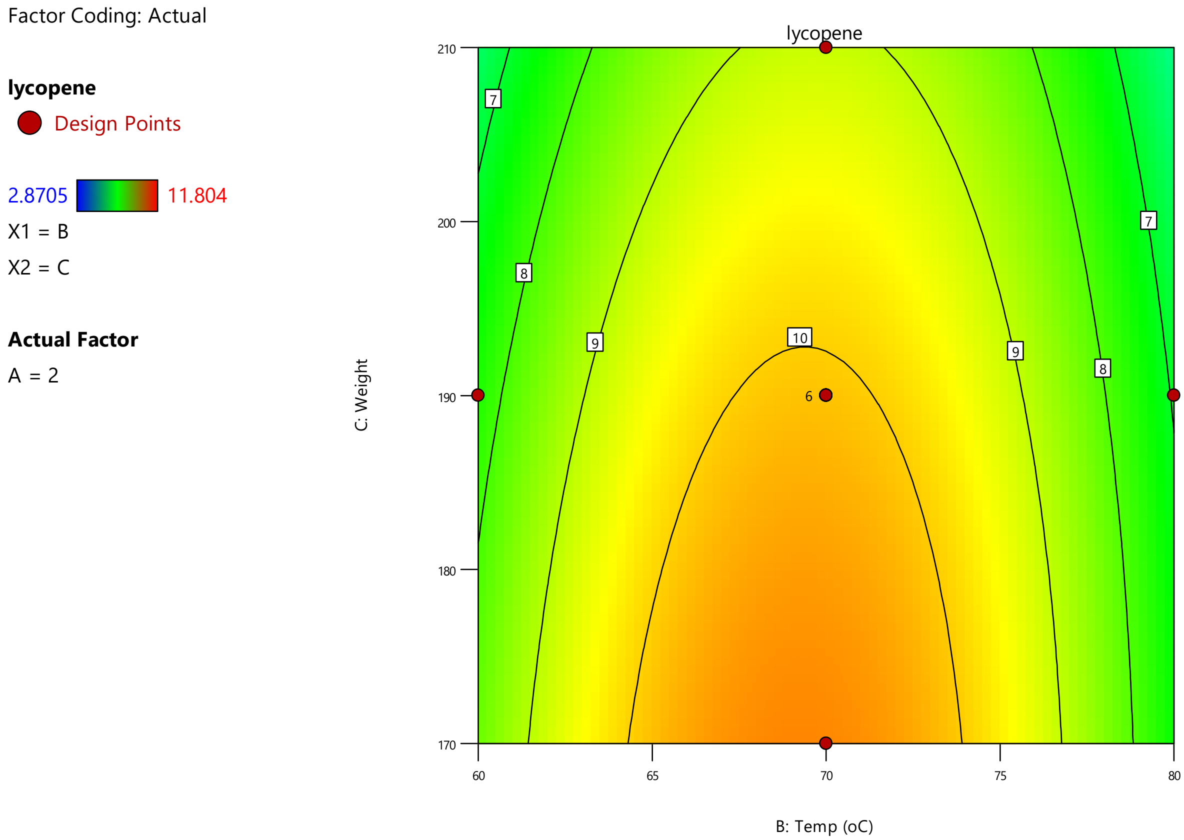

Fig 7: Contour showing the interaction effect of weight of tomato pulp and temperature on lycopene content of tomato powder

Figure 7 shows that the temperature increased from 60 – 63 ^{o}C and the weight of tomato pulp increased from 182 – 203 g/m^2, the lycopene content of the tomato powder produced decreased from 7 - 8 %.

Total Sugar

From Table 3 the sugar level of the foam mats dried tomato powder ranges from 0.002 to 0.0012 mmol/L. While the sugar content of the oven dried tomato powder ranges from 0.0001 to 0.0008 at 70 ^{o}C and 80 ^{o}C. The samples had significant difference, though some samples were similar. This is different with the works [26] whose values were 4% for fresh tomato and 1.11–3.19 % for foam mats dried tomato. Generally, all fresh tomatoes are low in sugars and because they fall low on the glycemic index, they don't usually have a significant impact on blood sugar levels.

$$Total\ Sugar = 0.0009 + 0.0001A + 0.0001B + 0.0000C + 0.0000AB + 0.0000AC - 0.0001BC - 0.0001A^2 - 0.0001B^2 - 0.0004C^2 \quad (12)$$

The mathematical model for the moisture content of the tomato powder is presented in Eq. 12, while Figures 8, 9 and 10 shows its contours. Increasing the concentration of the foam stabilizer, temperature of drying and weight of tomato pulp increased the sugar level of the tomato powder. The interaction of concentration of foam stabilizer and drying temperature (AB), concentration of foam stabilizer and weight of tomato pulp (AC) showed positive coefficient which signifies an increase in sugar level of the tomato powder. Contrarily, interaction of temperature and weight of tomato pulp (BC) showed negative coefficient which implies that if the interaction of temperature and weight of tomato pulp is increased, the sugar level will reduce in similar fashion. Squares of A, B, and C would decrease the sugar level of the powder.

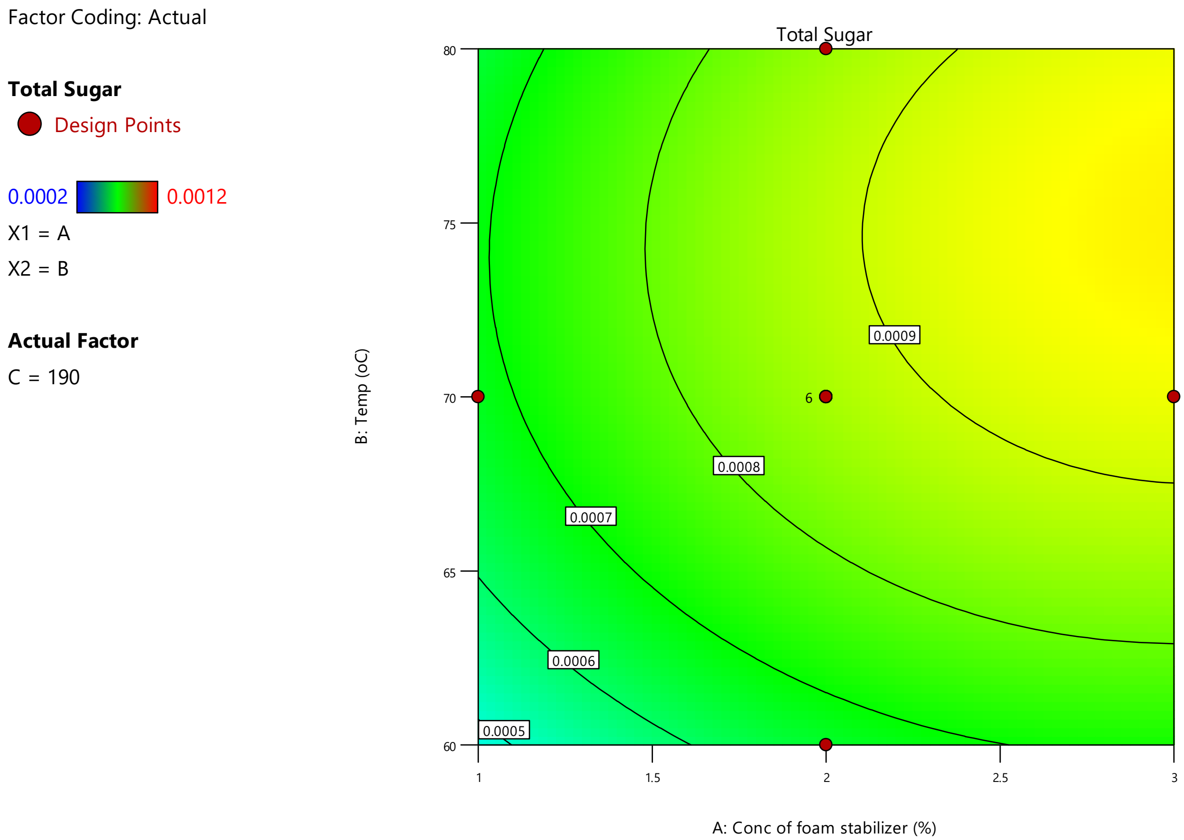

Fig 8: Contour showing the interaction effect of drying temperature and concentration of foam stabilizer on total sugar level of foam mat dried tomato powder.

Figure 8 shows that as the concentration of foam stabilizer increased from 1.59 – 2.5 % and the drying temperature increased from 64 - 80 ºC, the sugar level of the tomato powder produced decreased from 0.0007 – 0.0005 %.

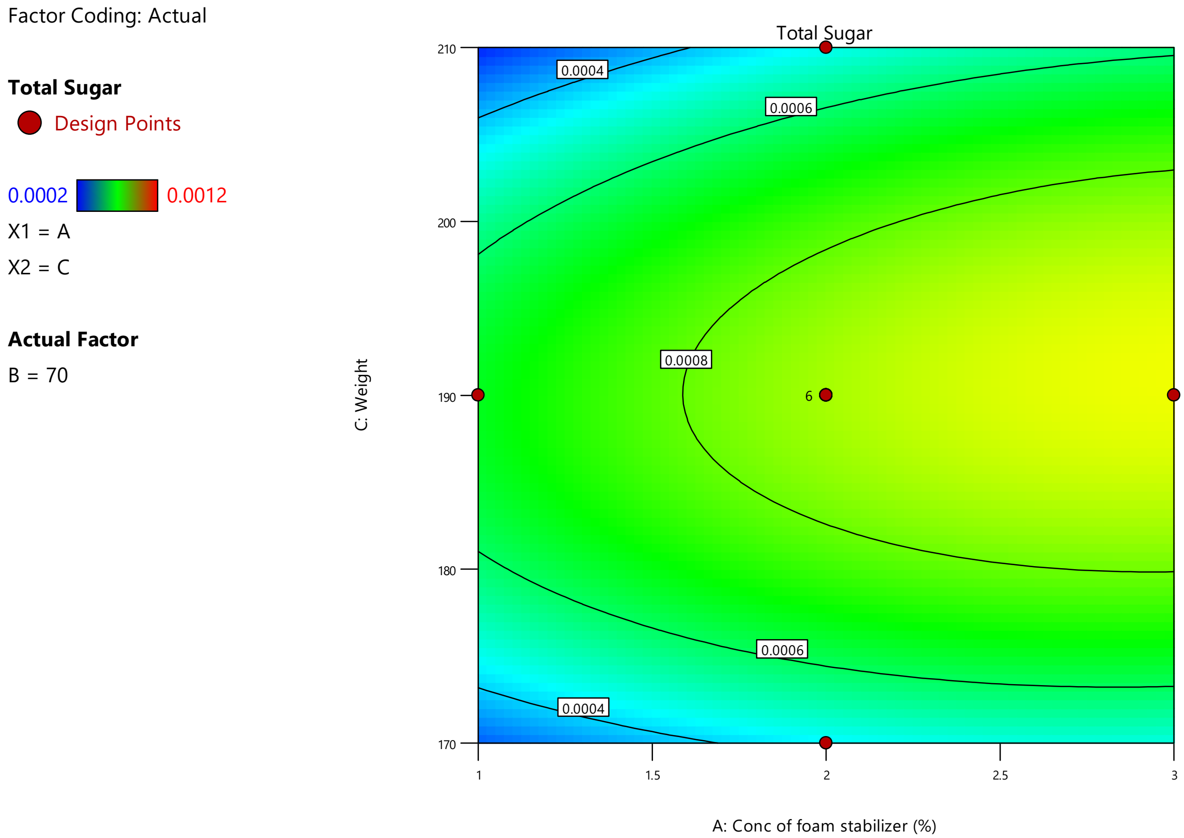

Fig 9: Contour showing the interaction effect of weight of tomato pulp and concentration of foam stabilizer on total sugar level of foam mat dried tomato powder.

Figure 9 shows that as foam stabilizer increased from 1.66 – 2.99 % and the weight of tomato pulp increased from 173 – 181 g/m^2, the sugar level of the tomato powder produced decreased from 0.0006 – 0.0004 %.

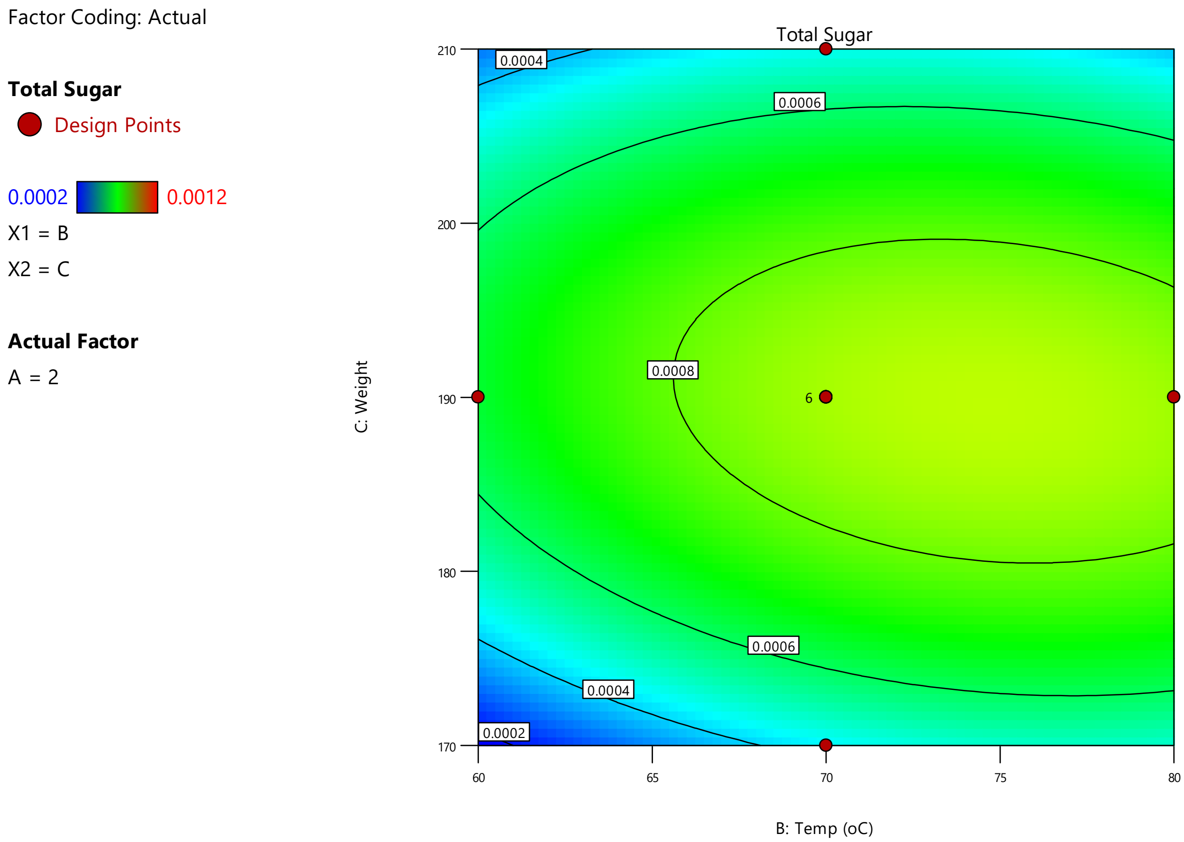

Fig.10: Contour showing the interaction effect of drying temperature and weight of tomato pulp on total sugar level of foam mat dried tomato powder.

Figure 10 shows that the temperature increased from 67 – 79 °C and the weight of tomato pulp increased from 176 – 184 g/m^2, the sugar level of the tomato powder produced decreased from 0.0006 – 0.0004 %.

After running the prediction of actual and predicted values of total sugar, it was observed that there was a strong positive relationship between the two variables. This was reflected in a Pearson correlation coefficient of 0.857. This high coefficient indicates that as the actual value of total sugar increases, the predicted value also tends to increase. This strong correlation is considered significant, which means that it is unlikely to be due to chance and is likely to reflect a true relationship between the actual and predicted values of total sugar.

Ascorbic Acid

The results of this study showed that there is an increase in ascorbic acid content. The ascorbic acid of the oven dried tomato ranged from 60.13 to 70.81 mgL^{-1} and in reconstituted foam mat dried tomato powder it was within the range 122.03 to 127.50 mgL^{-1}. The result showed that the foam mats dried tomatoes have higher concentration of ascorbic acid than the oven dried tomato where the ascorbic acid was decreased due to rise in temperature. This indicated heat-sensitive ascorbic acid was destroyed with the rise of temperature in the oven dried tomato. [30] reported that hot air drying of tomato reduces the ascorbic acid content significantly at high temperature. Similar types of results were also reported by other researchers for passion fruit aril [31], pulses [32], muskmelon [33], foam mat dried mango powder [34], and onion [35] following heat treatment. Ascorbic acid (vitamin C) is a heat-sensitive water-soluble vitamin. As food processing largely depends on heat processing so the determination of ascorbic acid in processed food is necessary for products that are rich in vitamin C in fresh condition.

$$Ascorbic\ Aci = 122.51 - 0.8140A + 0.5240B + 0.4520C + 0.8325AB + 0.1625AC - 0.8275BC + 1.15A^2 + 0.1568B^2 + 1.14C^2 \quad (13)$$

The mathematical model for the ascorbic acid content of the tomato powder is presented in Eq. 13, while Figures 11, 12 and 13 shows its contours. Increasing the temperature of drying and weight of tomato pulp increased the ascorbic acid content of the tomato powder. Temperature had more effect in increasing the ascorbic acid content of the tomato powder because the positive coefficient of temperature (0.5240) is higher than that of weight of tomato pulp (0.4520). The interaction of concentration of foam stabilizer and drying temperature (AB) also showed positive coefficient (0.8325). Contrarily, concentration of foam stabilizer (A) showed negative coefficient which implies that if the concentration of weight of tomato pulp is increased, the ascorbic acid content will reduce. The interaction of foam stabilizer and weight of tomato pulp (AC) showed positive coefficient, suggesting an increase in ascorbic acid content of the powder. The interaction of the temperature and weight of the pulp (BC) showed negative coefficient (- 0.8275) This implies that it caused a significant decrease in ascorbic acid content of the tomato powder. Squares of A, B and C would increase the ascorbic acid content of the tomato powder.

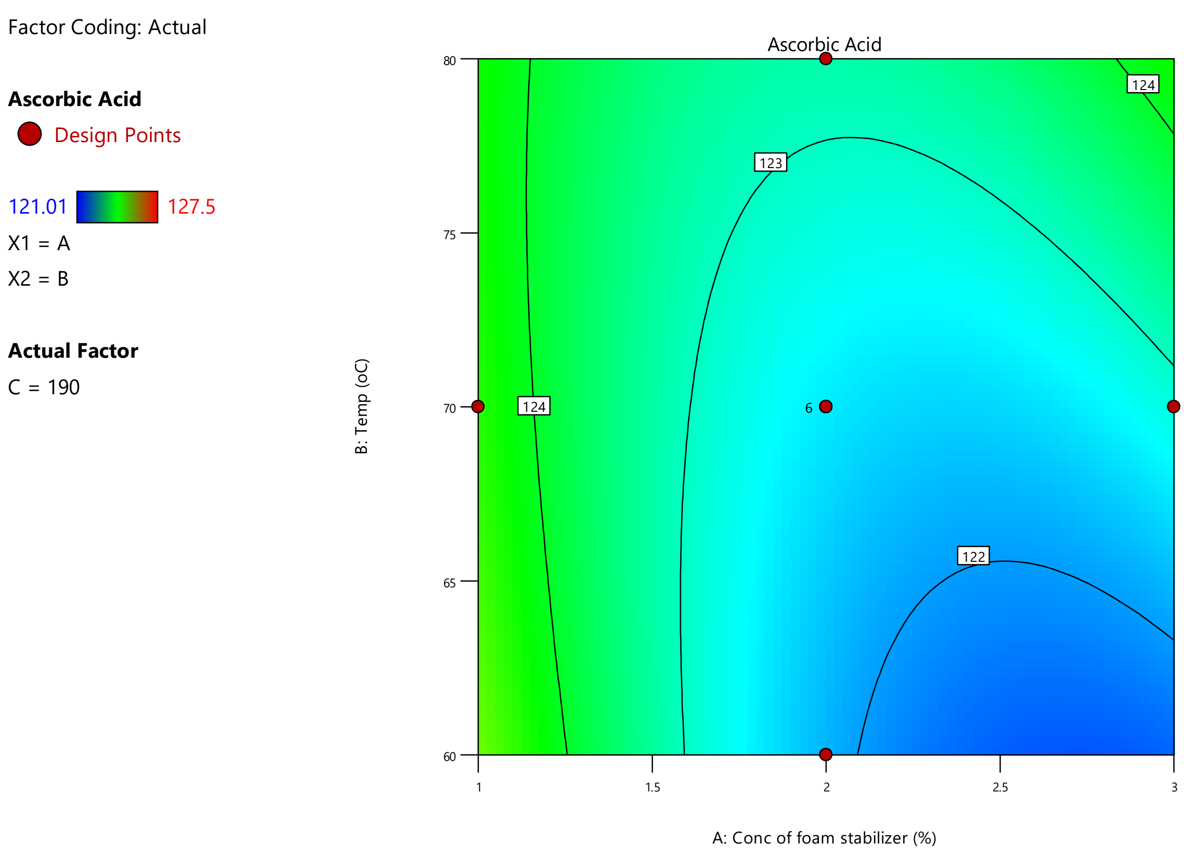

Fig 11: Contour of interaction effect of temperature and concentration of foam stabilizer on the ascorbic content of foam mat dried tomato powder.

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Vol.121, 2023

Figure 11 shows that as the concentration of foam stabilizer increased from 1.58 – 2.08 % and the drying temperature increased from 63 – 71 ºC, ascorbic acid content of the tomato powder produced increased from 122 - 123 mgL^{-1}.

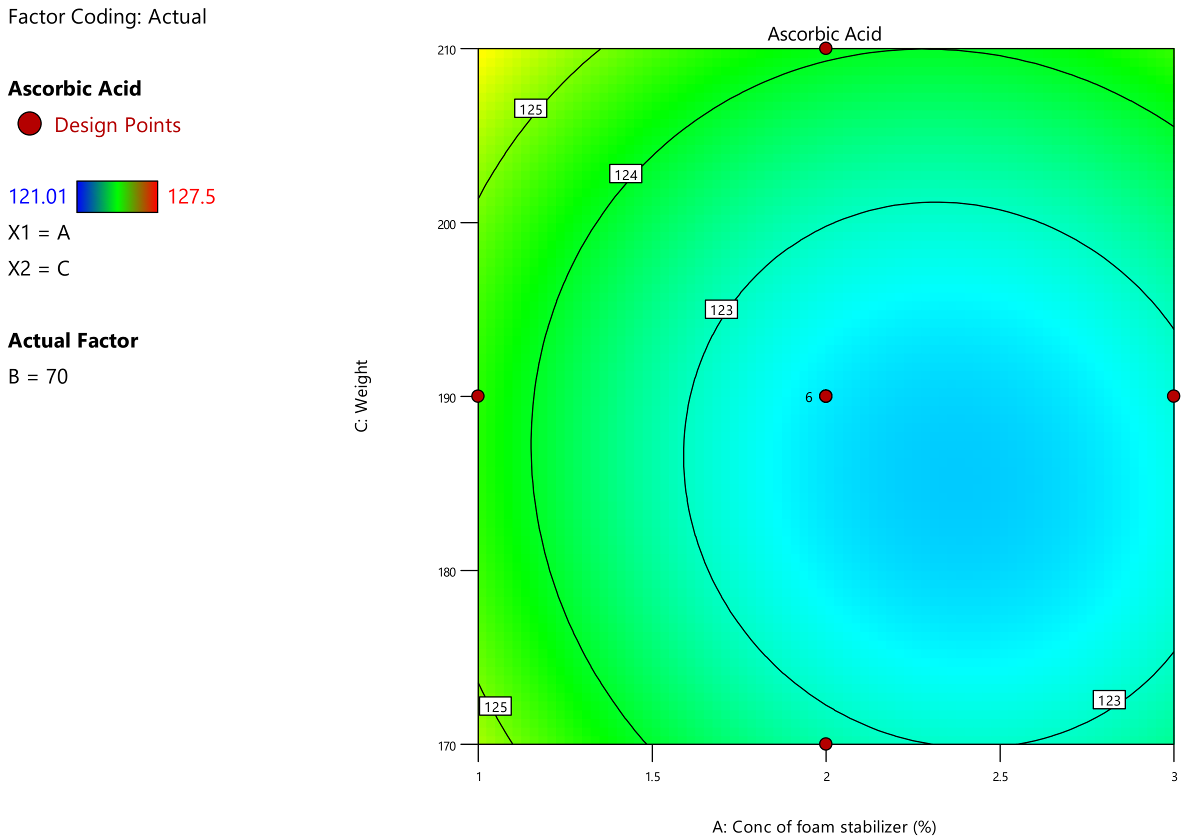

Fig 12: Contour of interaction effect of concentration of foam stabilizer and weight of tomato pulp on the ascorbic content of foam mat dried tomato powder.

Figure 12 shows that as the concentration of foam stabilizer increased from 1.58 – 2.08 % and the drying temperature increased from 63 – 71 ºC, ascorbic acid content of the tomato powder produced increased from 122 - 123 mgL^{-1}.

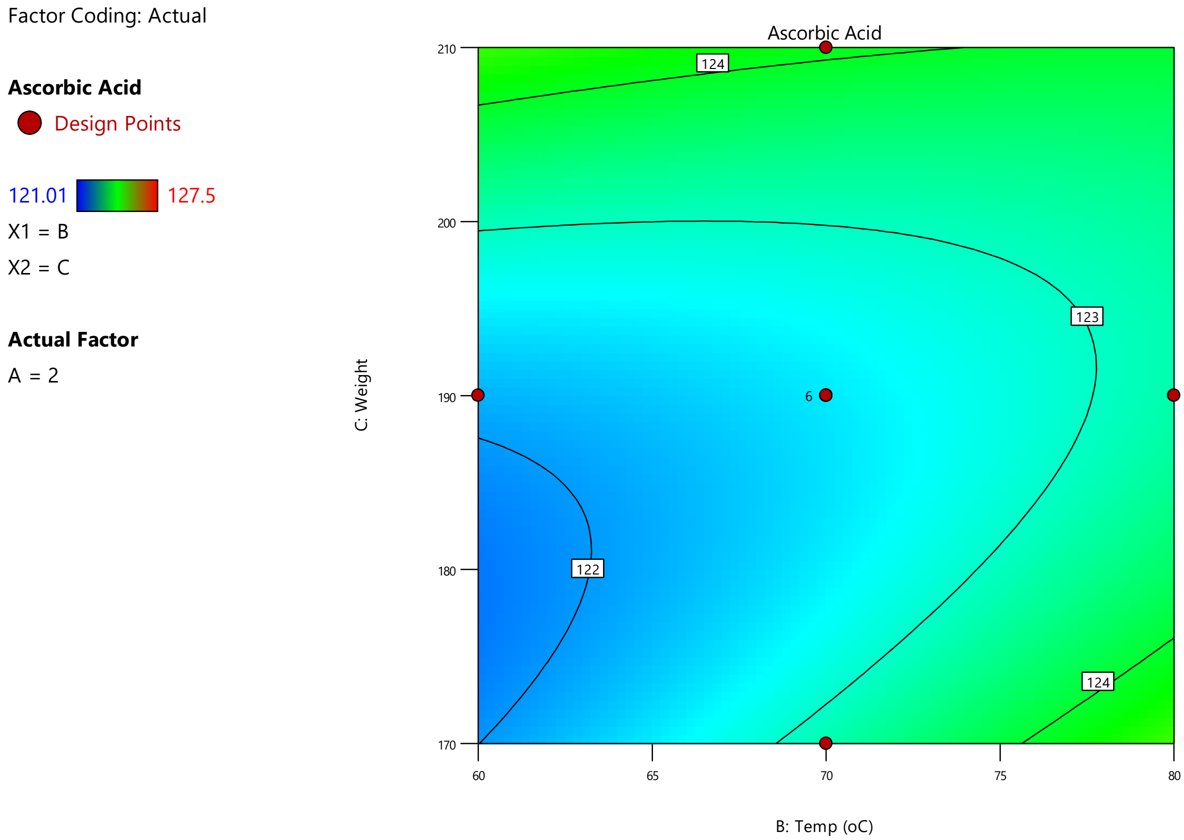

Fig 13: Contour of interaction effect of temperature and weight of tomato pulp on the ascorbic content of foam mat dried tomato powder.

Figure 13 shows that as the temperature increased from 68 – 75 °C and the weight of tomato pulp increased from 199 – 206 g/m^2, the ascorbic acid content of the tomato powder increased from 123 – 124 mgL^{-1}

β-Carotene

The β-Carotene is important pro vitamin A which is water-soluble and heat-sensitive. From table 3 the β-Carotene content of oven dried tomato was 0.83, 0.64, 0.56 mg at 60 °C, 70 °C and 80 °C and in reconstituted foam mat dried tomato powder it ranges from 1.12 to 2.471 mg. Sample 12 has the lowest β-Carotene content while sample 16 has the highest β-Carotene content. The high processing temperatures significantly degrade β-Carotene in the oven dried tomato powder while in foam mat dried it was retained. The β-Carotene content decreased due to its heat sensitive nature and increased with increasing protein concentration. The findings of the present study are in good harmony with [36] and [37] who informed that degradation of β-carotene was attributable to drying temperature in cherry tomato and dried Gacril, respectively. [38] also found similar results for foam mat dried mango pulp and reported that it may be due to increase in the surface area caused by increase in foaming agent concentration and thus all particles are dried at low temperature.

$$\beta - Carotene = 1.43 + 0.1530A - 0.1360B - 0.0540C - 0.2088AB + 0.0612AC - 0.0537BC + 0.2691A^2 + 0.1541B^2 - 0.0659C^2 \quad (14)$$

The mathematical model for the β-carotene content of the tomato powder is presented in Eq. 14, while Figures 14, 15 and 16 shows its contours. Increasing the temperature of drying and weight of tomato pulp decreased the β-carotene content of the tomato powder. Temperature caused greater decrease in β-carotene content than the weight of tomato pulp because the coefficient of temperature (-0.1360) is higher than that of the weight of tomato pulp (-0.0540). The interaction of concentration of foam stabilizer and drying temperature (AB) also showed negative coefficient (-0.2088). Contrarily, concentration of foam stabilizer(A) showed positive coefficient which implies that if the concentration of weight of foam stabilizer is increased, the β-carotene content will increase in similar fashion. The interaction of temperature and weight of tomato pulp (BC) showed negative coefficient, suggesting that it has a decreasing effect on β-carotene content of the powder.

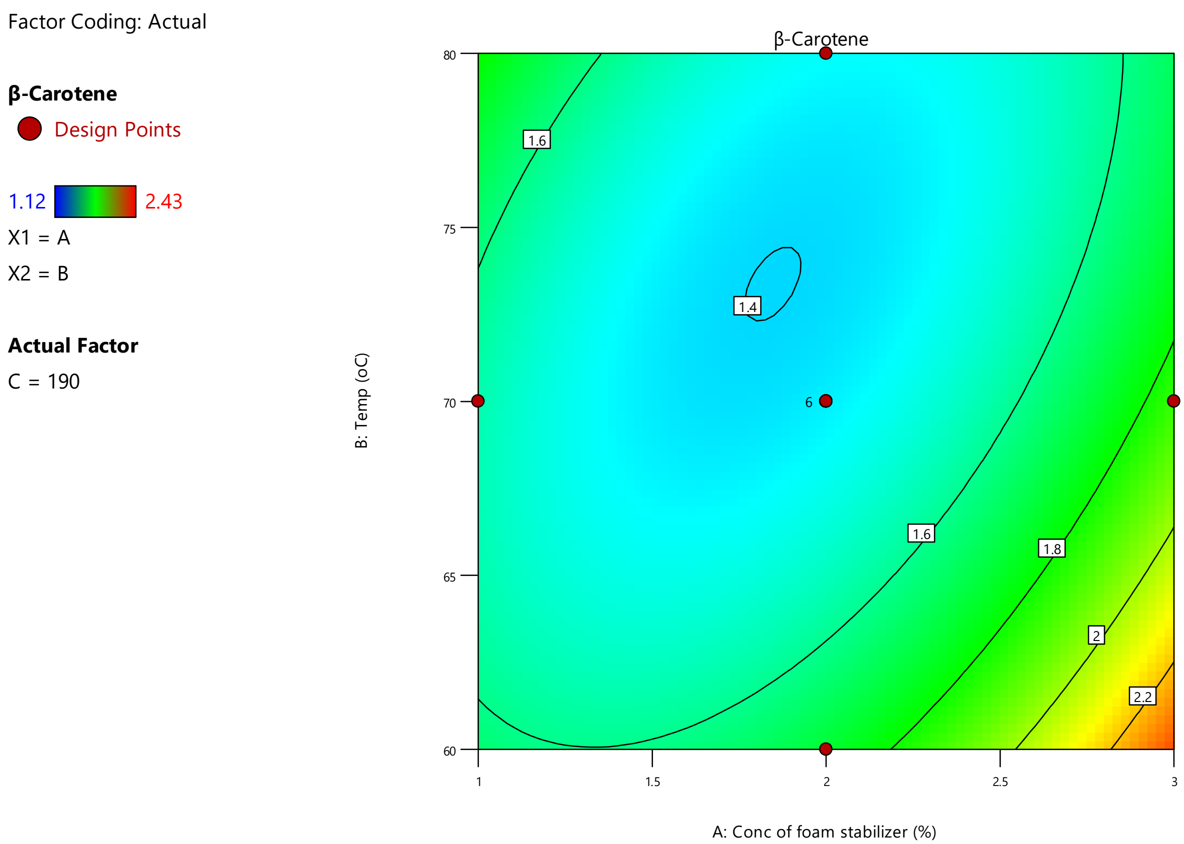

Fig 14: Contour of interaction effect of temperature and concentration of foam stabilizer on the β-carotene content of foam mat dried tomato powder.

Figure 14 shows that foam stabilizer increased from 2.28 – 2.65 % and the weight of tomato pulp increased from 207 – 210 g/m^2, the β-carotene content of the tomato powder produced decreased from 1.6 – 1.4 mg %.

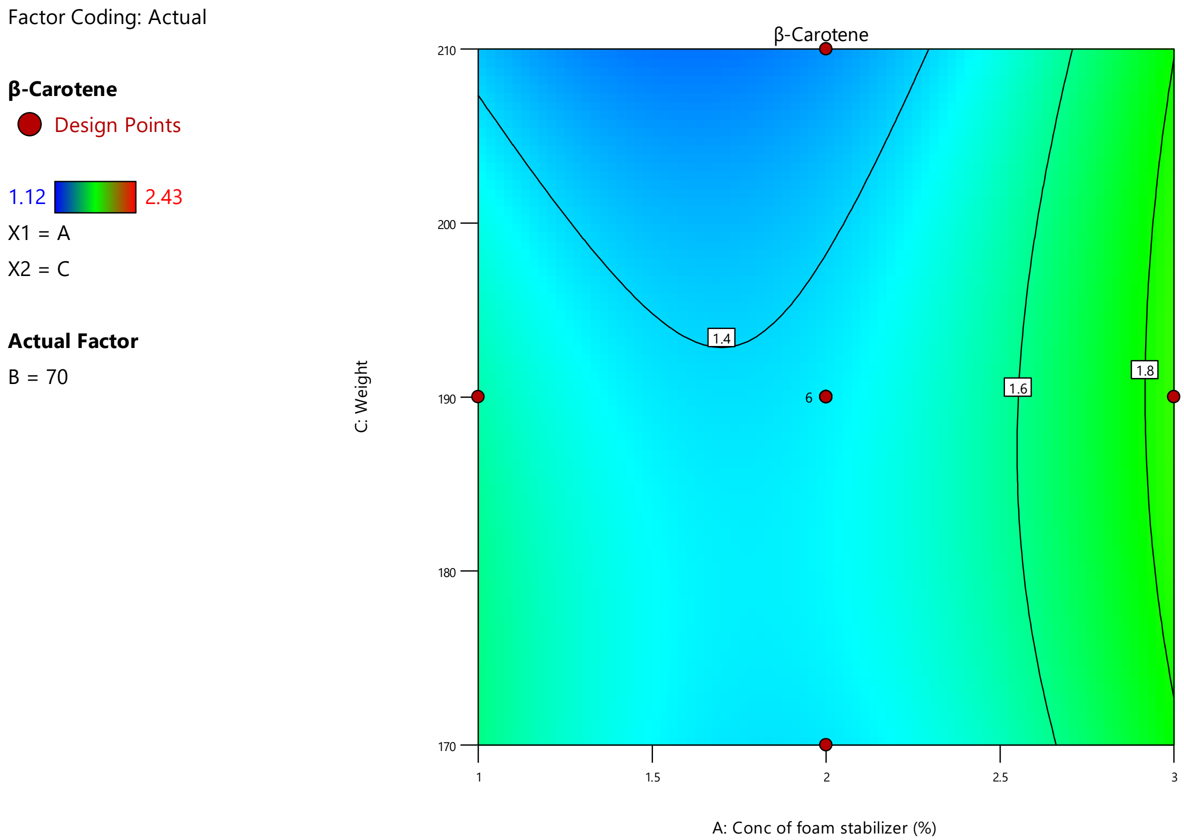

Fig.15: Contour of interaction effect of weight of tomato pulp and concentration of foam stabilizer on the β-carotene content of foam mat dried tomato powder.

Figure 15 shows that as the concentration of foam stabilizer increased from 2.19 – 2.55 % and the drying temperature increased from 66 – 71 ºC, the β-carotene content of the tomato powder produced decreased from 2 – 1.8 mg.

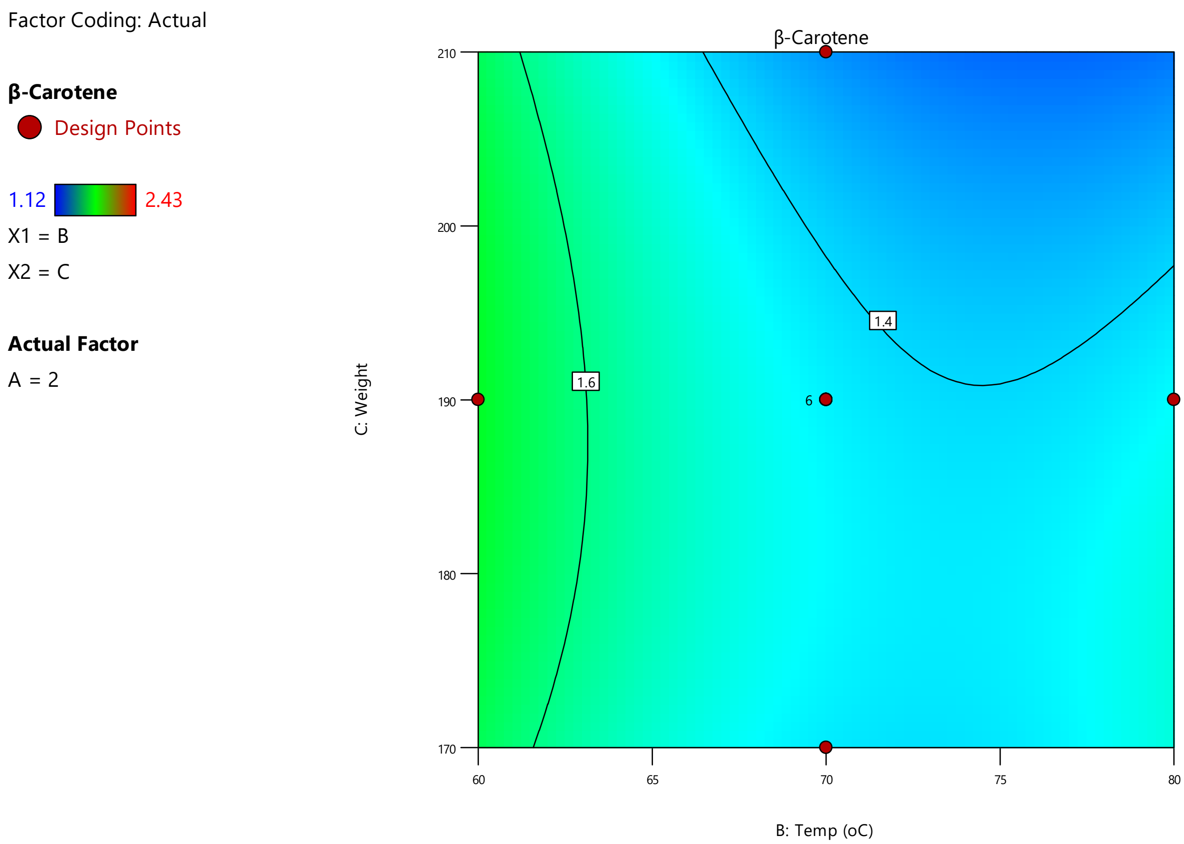

Fig 16: Contour of interaction effect of temperature and weight of tomato pulp on the β-carotene content of foam mat dried tomato powder.

Figure 16 shows that the temperature increased from 61 – 66 ºC and the weight of tomato pulp increased from 197 – 210 g/m^2, the β-carotene content of the tomato powder produced decreased from 1.6 – 1.4 mg.

After examining the prediction of actual and predicted values of beta-carotene, it was noted that there was a weak negative relationship between the two variables. The Pearson correlation coefficient of -0.08 indicates that as the actual value of beta-carotene increases, the predicted value tends to decrease. However, the weak nature of this correlation means that it is not strong enough to be considered statistically significant. As a result, the negative correlation should not be relied upon for making predictions or drawing conclusions about the relationship between the actual and predicted values of beta-carotene.

Total Soluble Solids

Total soluble solids of different samples at different drying temperatures are presented in Table 3 For oven dried tomato samples, TSS was found to be 0.80, 1.35, 1.60 °Brix and in reconstituted foam mat dried tomato powder it was varied from 4.70 to 7.21 °Brix. There was a significant increase in TSS content of the foam mat dried tomato powder. TSS content was decreased with the increase of temperature because of the reduction of some heat-sensitive components presents in the powder. Temperature has a significant effect on the TSS content of the foam mat and oven dried tomato powder. Similar types of results were noticed by other researchers for foam mat dried tomato powder [38] and alphonso mango powder [39].

$$TSS = 5.64 + 0.2590A + 0.7670B - 0.0380C \quad (15)$$

The mathematical model of the total soluble solids content of the tomato powder is shown Eq.15 and Figure 17. Increasing the concentration of foam stabilizer and temperature increases the TSS content of the foam mat dried tomato powder. However, weight of the pulp reduced the TSS content of the foam mat dried tomato powder, this because the weight of the pulp has a negative coefficient.

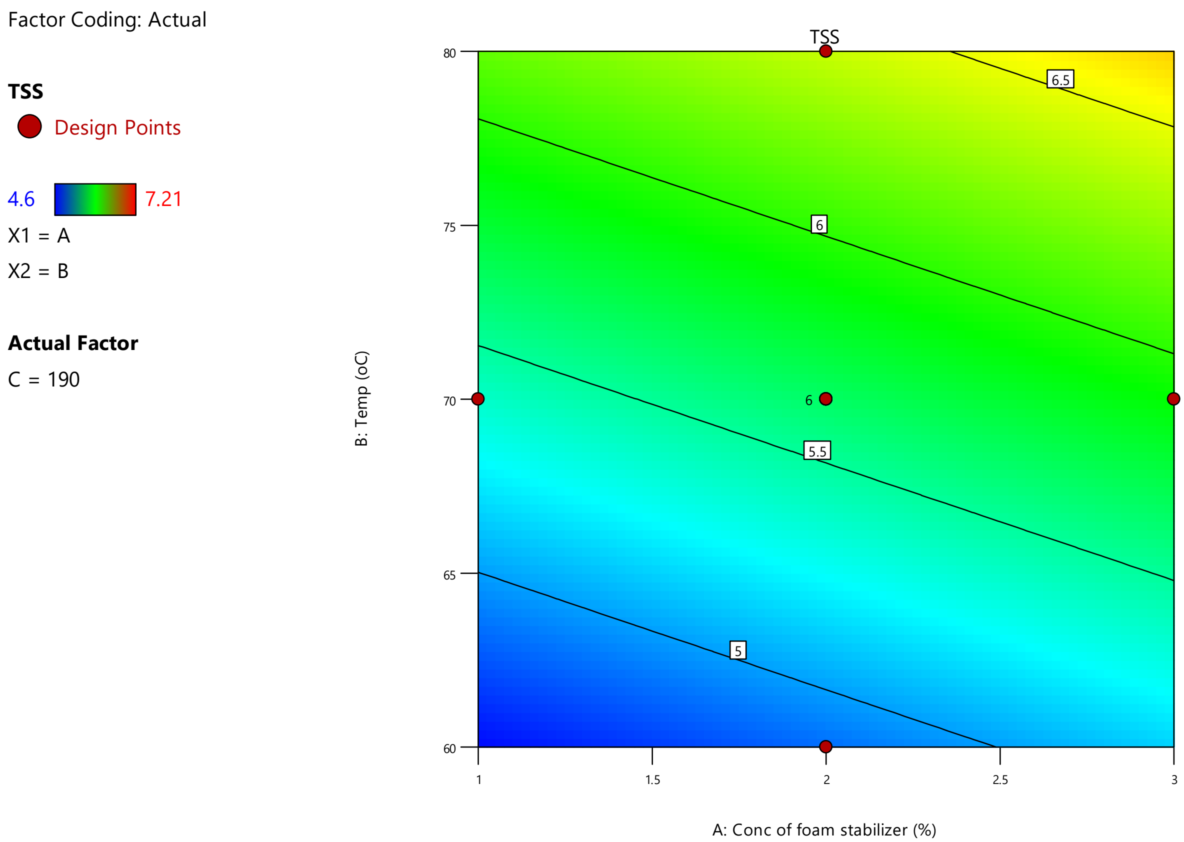

Fig. 17: Contour of interaction effect of temperature and concentration of foam stabilizer on the total soluble solids content of the foam mat dried tomato powder.

Figure 17 shows the interaction effect of temperature and concentration of foam stabilizer. It shows that as the concentration of foam stabilizer increased from 1 – 2.5 % and the drying temperature increased from 65 – 71 °C, the TSS of the tomato powder produced increased from 5 – 5.5 °Brix.

Table 8: Correlation of the predicted and Actual Value of total soluble solids of the foam mat dried tomato powder

		Predicted	Actual
Predicted	Pearson Correlation	1	.801**
	Sig. (2-tailed)		.000
	N	20	20
Actual	Pearson Correlation	.801**	1
	Sig. (2-tailed)	.000	
	N	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

From Table 8 the Pearson correlation at 0.801 between an actual and predicted value of the total soluble solids that was significant with a positive nature indicates that there is a strong and statistically significant ($p<0.05$) relationship between the two variables of the total soluble solids. A coefficient of 0.801 indicates a strong relationship. The fact that the correlation was significant meant that the observed relationship between the variables was unlikely to be due to chance, and was a reliable indication of a true underlying relationship between the two variables. The positive nature of the correlation indicates that as the actual value increases, the predicted value also tends to increase. This suggests that the predicted values are accurate and reliable, and can be used to make predictions about the actual values.

Numeric Optimization for the Chemical Composition

Table 6 Numeric Optimization solution for the chemical composition of foam mat dried tomato

Variables	Selected Values	Desirability
Foam Stabilizer	1	0.716 (72 %)
Temperature	63.0955	
Weight of pulp	171.774	
Titratable Acidity	1.75287	
pH	4.57274	
Lycopene	10.6864	
Total Sugar	0.000198972	
Ascorbic Acid	124.914	
Beta-Carotene	1.58916	
Total Soluble Solids	4.88648	

Table 6 shows the generated Numerical Optimization solution of the chemical composition of foam mat dried tomato powder. The main criteria for constraints optimization of process parameters for the chemical composition were minimum foam stabilizer, minimum temperature, weight of tomato pulp in range, minimum titratable acidity, minimum pH, maximum lycopene content, Total sugar in range, maximum ascorbic acid, maximum β-carotene, minimum total soluble solids. which generated the solution in Table 6 with desirability of 71.6 %. The percentage desirability is high and acceptable. However, desirability of 100% is the most ideal if it could be obtained. It shows that if the selected critical values of 1.0 % foam stabilizer, temperature at 63 ºC, weight of pulp at 172 g/m^2 are employed in the production of foam mat dried tomato powder would exhibit chemical composition of 1.75, 4.57, 10.68, 0.00019, 1.59, 4.89 for TA, pH, Lycopene, Total Sugar, Ascorbic Acid, Beta-Carotene and TSS respectively, with the desirability of 0.716 (72 %). Figures 23, 24 and 25 shows the optimization plot of interaction effect of temperature and concentration of foam stabilizer, weight of tomato pulp and temperature, concentration of foam stabilizer and weight of tomato pulp respectively

Conclusion

In conclusion, this study has shown that foam mat drying is an effective method for retaining the nutritional qualities of tomato when compared to oven drying. From the responses and results obtained from this research, it can be concluded that the samples differ significantly (p<0.05) in some of the physical and chemical properties. Foam mat drying is effective in retaining the nutritional qualities of tomato when compared to oven drying of tomato. The results of the study indicate that temperature, foam stabilizer, and weight of the pulp have a significant effect on some of the parameters in physical and chemical properties. The study also revealed that the foam mat dried tomato powder had better flowability and loose bulk density as compared to the oven dried tomato powder. The lycopene content, beta-carotene and total soluble solids was found to be higher in foam mat dried tomato powder as compared to oven dried tomato powder.

The concentration of foaming stabilizer was found to have a significant effect on the bulk density, tapp density, pH, ascorbic acid and beta-carotene of tomato powder produced. However, it was found to not have a significant effect on other properties. The weight of the tomato powder was found to have a significant effect on titratable acidity. The drying temperature was found to have a significant effect on β-Carotene of the tomato powder produced. Based on these results, it can be concluded that foam mat drying is effective in retaining the color, odor and taste of tomato and that a good reconstituted tomato paste can be made from it. The results of this study provide valuable information for the development of new and improved tomato-based food products that have high nutritional value. Based on the results of the optimization, the optimum conditions for foam mat drying of tomato were determined to be a concentration of 1% foaming stabilizer, a weight of 171 g/m^2 for the tomato pulp, and a drying temperature of 63^{o}C with desirability of 70% for the chemical properties and a concentration of 1% foaming stabilizer, a weight of 209 g/m^2 for the tomato pulp, and a drying temperature of 60^{o}C with desirability of 96 % for the physical properties.

Recommendation

From the knowledge gained in the course of this research, the following are been recommended that;

1. As a means of storage, it is recommended that foam mat dried tomato can be stored and then be used during tomato scarcity since tomato has its season.
2. A topic on Effects of blending time of tomato and biting time of the egg which serves as the foam stabilizer in production of foam mat dried tomato powder using response surface methodology should be carried out for further research.
3. A Further study should be carried out on the storage property of foam mat dried tomato powder to estimate how long it can stay and still retain all the nutritional properties.

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Competing Interest

Authors have declared that no competing interests exist.

Authors' Contributions

Each of the authors of this manuscript has made significant contributions to the research and preparation of the manuscript. The specific contributions of each author are outlined below:

Author 1: Mogor Chidimma contributed to the conceptualization and design of the study, data collection and analysis, and drafting and revision of the manuscript.

Author 2: Ishiwu C.N contributed to the interpretation of the data, critical review of the manuscript, and final approval of the submitted version.

Author 3: Okocha Sunday contributed to the literature review, data interpretation, and manuscript revision.

Author 4: Mofunanya G.N contributed to the data analysis, critical review of the manuscript, and final approval of the submitted version.

All authors have read and approved the final manuscript for submission and take full responsibility for the accuracy and integrity of the research presented.

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