Some Nutritional and Physical Characteristics of Kerewa and UC-82B Tomato powder as Affected by Concentration Levels of Foaming Agents(Glycerol Monostrate (GMS) and Skimmed Milk) and Microwave Power Using Foam Mat Drying Method

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ABSTRACT

Moisture content of tomato (Licopersicon esculentum Mill.) is very high, so easily damaged due to physical impact, enzyme and microbes' activity. Further processing is necessary in order to improve shelf life, one way is drying method. Tomato powder was produced from two varieties (Kerewa and UC-82B) using Foam mat drying method Glycerol Monostrate (GMS) and skimmed milk were used as forming agents at concentration level of 1%, 2% and 3% with Carboxyl Methyl Cellulose (CMC) as a stabilizer at different levels of microwave power (240W, 385W and 540W). The effects of concentration level and microwave power level was determined on quality and nutritional properties (colour, Rehydration ratio, lycopene and ascorbic acid) of the reconstituted tomato powder. The color change was affected by all factors with UC-82B variety having the maximum color change, indicating that Kerewa variety would be preferable in terms of color. Rehydration ratio for both varieties was constant for all levels of factors considered while Concentration levels did not significantly affect the properties. Microwave power affected the color change and ascorbic acid content of the finished products. There was an increased level of Color change and reduction in Ascorbic acid with increased power level. Lycopene contents in the final products was higher for skimmed milk as compared to GMS.

Keywords: *Foam Mat Drying, Colour Change, Rehydration Ratio, Ascorbic acid, Lycopene*

INTRODUCTION

Tomato is the second largest vegetable crop produced and contributes 7% of the world tomato production. Due to high moisture content (93–95%), it is highly perishable, which poses a big problem for its storage and transportation that causes heavy losses. It creates glut during the production season and becomes scanty during the off-season. To overcome these post-harvest losses, it must be processed into shelf stable products for its availability in the off-season. Tomato is used in various forms in its fresh , dried(powder or solid) and processed (juice, puree, sauce) states.

Drying is one of the most used processes to improve food stability because it considerably reduces the water activity of the material, reduces the microbiological activity and minimizes physical and chemical alterations during storage (Mayor *and Sereno.*, 2004). The main advantages of foam drying are lower temperatures and shorter drying times compared to drying non-foamed materials in the same dryer type (Thuwapanichayanan *et al.,* 2012). In foam mat drying, foam stabilizers are added to the food concentrate or paste, and a mixer is used to whip the mixture thus incorporating and subdividing gas bubble within the paste to form a stiff foam. The foam is then dried in hot air stream, cooled, removed from tray, milled, and packaged. Foam drying allows for the processing of biomaterials that are difficult to dry, such as tomato Paste and also allow for production of materials that can easily rehydrate and retain several quality indicators, such as color, aroma, texture and nutritional values.

Foaming agents are used to incorporate the air in concentrates which result into decrease in drying rate. Performance of foaming agents can be measured by its foaming properties and final qualities of product(powder). Foaming properties of different foaming agents can be affected by many factors such as concentration of foaming agents, Solid content of concentrates, whipping time and room temperature during whipping. Foam-mat drying requires stiff stable foams which are not readily made from many food concentrates especially food with low protein content, unless there is an addition of a small quantity of foaming agents or foam stabilizers. Foam stabilizers are added at different levels to varying composition of the food concentrate, and their performances could be measured by their foaming, reconstitution, and sensory attributes. Over the years, foam-mat drying has been applied to many fruits including tomato paste (Lewicki 1975), mango (Cooke *et al.*, 1976), soymilk (Akintoye *et al.*, 1991), and bananas (Sankat *et al.*, 2004). The objective of the study is to determine the effect of foaming agent, and microwave power on some physio-chemical properties (Colour, Rehydration Ratio) and nutritional properties (lycopene and ascorbic acid) of the reconstituted dry tomato powder from two tomato varieties (Kerewa and UC-82B)

MATERIALS AND METHOD

Sample preparation

Tomatoes varieties were procured from local vegetable markets in Ogun state. The varieties were identified as UC-82B and Yoruba-Kerewa. Tomatoes that appeared damaged was removed by hand picking, manually sorted into sizes and graded visually into red, orange and green colour. Only red and orange clean and equal sized tomatoes were used as samples and stored at 5 ± 0.5°C before use in any experimental run. Prior to commencement of experiment required pack is brought out and allowed to thaw before use. The tomatoes were then cut into slices of approximately 10 ± 0.1 mm thick using a sharp stainless-steel knife and deseeded. The direction of cut was perpendicular to the vertical axis of the tomato while a micrometre was used to check the thickness and uniformity of each slice at three different locations. About 50 to 60 g of tomato slices ranging from 2 to 4 cm in diameter was carefully arranged as a single layer on a sample tray for use in the drying experiment. The initial moisture content of the tomato slices, expressed in g water /g dry matter was determined using gravimetric method by oven drying at 105 ± 2 ºC until there was no appreciable weight change (Aghbashlo, *et al.,* 2009; Darvishi *et al.,* 2013).

All tomatoes varieties were pretreated by blanching the deseeded tomato slices in water at 94ºC for 3 minutes to deactivate any enzyme activity and as well hinder the growth of microbes.

Preparation of Tomato Puree and Foamed tomatoes sample

The blanched deseeded tomatoes were blended with an electric jug blender (Model no. MC-BL6776J) to form tomato paste. The tomato paste was poured to fill the sample can in according to the required quantity.

The tomato puree was homogenized and foaming was achieved by adding foaming agents, such as GMS (Glycerol Monostrate) (3%, 2%, 1%) and skimmed milk in (3%, 2%, 1%) concentrations and CMC (carboxy methyl cellulose) (1.5%) as a stabilizer which was prepared by adding warm water to the required concentrate and was homogenized before been added to the tomato puree. Using an electric blender, the samples were whipped for about 5 to 7 minutes to obtain a consistent foam. The foamed juice was poured into the sample can and dried in a microwave at a drying power of 230W, 385W and 540W.

Equipment Setup and Drying Procedure

The drying setup consisted of a domestic microwave oven (Mikrowelle Model D70D 17R, Mikrowelle Company, Germany) with a cavity of 29 cm x 25 cm x 18 cm and a rotating glass plate. It operates at 2450 MHz with a maximum power rating of 750 W. Drying experiments were carried out with four power levels of 230, 385 and 540W corresponding to three of the five power settings on the microwave control panel. Three microwave compatible plastic trays (10 cm in diameter and 3 cm deep) containing between 35 and 45 g of foamed sample each were arranged on the rotating tray to allow good absorption of the microwave energy. The temperature in the microwave cabinet was intermittently measured with an infrared thermometer by pointing into the oven as required. All experiments were carried out in triplicates samples and the mean value used for analysis.

Plate 1: Sorted and washed Yoruba Kerewa tomato

Plate 2: Sorted and washed Hausa UC-82B tomato

Plate 3: Deseeded Tomato

Plate 4: Foamed Tomato Puree

Determination of Color Change (ΔE)

A Colorimeter was used to obtain the colour parameter values of hunter L* (whiteness, darkness), a*(redness, greenness) and b*(yellowness, blueness) of tomatoes sample before and after each drying experiment. Total colour change (ΔE) is then calculated from L*, a* and b* using Equation 1 as reported by Dairo, et al, (2017). The data were collected in duplicate to obtain mean values.

$$\Delta E = \sqrt{(L_o - L*)^2 + (a_o - a*)^2 + (b_o - b*)^2} \qquad (1)$$

Rehydration ratio (RR)

The rehydration ration was determined according to (Singh *et al.*, 2010) which about 35ºC dried sample of about 4-5g was weighed and placed in 250ml beaker, 100ml of diluted water was added into the beaker and both sample and water was placed into a room temperature with temperature ranging between 32ºC and 35ºC. The sample was taken out of the beaker after 30 minutes and excess water was removed using absorbent paper. The dried sample was weighed using sensitive weighing scale and put back into the beaker. The procedure was repeated every 30 minutes using the replicates. The rehydration ratio (RR) was calculated using Equation 2

$$RR = \frac{W_r}{W_d} \qquad (2)$$

Where W_r is weight of rehydrated sample (g) and W_d is weight of dehydrated sample

Determination of Ascorbic Acid Content

Ascorbic acid was estimated using visual titration method as reported by Kadam *et al.* (2012). An aliquot of the sample was diluted to a fixed volume with 3% HPO_3 and then titrated with 2,6-dichlorophenolindophenol. A standard ascorbic acid solution of 5 mL was added to 5 mL of 3% HPO_3 and titrated with dye solution to a pink color, which will be persisted for 15 s. The dye factor, i.e., mg of ascorbic acid per ml of the dye, was determined using Equations 3 and 4.

$$D_F = \frac{0.5}{T} \qquad (3)$$

Ascorbic acid (mg/100 mL) of reconstituted juice was calculated using the formula:

$$A = \frac{T \times DF \times V_1}{V_2 \times V_3} \qquad (4)$$

Where, A is ascorbic acid in mg/100ml, T is titre; DF *is* Dye factor; V_1 volume made up; V_2 is aliquot of extract taken for estimation and V_3 is volume of sample taken for estimation.

Determination of Ascorbic Lycopene Content

Lycopene was determined a modified method of Rangana (1995) as described. Sample of dry tomato powder (500 mg) was homogenized and agitated with 5 ml of petroleum ether, and allowed to settle down, and then supernatant was decanted. The procedure was repeated until no color was obtained and supernatants were pooled, and final volume will made up to 10 ml. The absorption of the supernatant was recorded at 505 nm on UV visible spectrophotometer. Lycopene content was calculated from Equation 5.

$$L = \frac{3.1206 \times V_F \times O \times 100}{W \times 1000} \qquad (5)$$

Where L is lycopene content in mg/100g, V_F is final volume, O is optical density and W is weight of samples taken in gm.

Experimental Design and Statistical Analysis

A completely randomized design (CRD) was used as experimental design while effects of independent variables on responses were determined by the analysis of variance (ANOVA), graphs and other descriptive statistics.

RESULTS AND DISCUSSION

Effect of foaming agent and concentration level on Lycopene Contents of Kerewa and UC-82B tomato varieties

Table 1 presents the effect of foaming agent and foaming agent concentration level on the lycopene and ascorbic acid contents of Kerewa tomato. The values of lycopene content varied between 1.71 to 6.61(mg/100) for skimmed milk and 1.54 to 5.19 (mg/100) for skimmed milk with values for skimmed milk always higher than values obtained for GMS at all power levels considered.

Table 1. Effect of foaming agent and concentration level on Lycopene content of Kerewa and UC-82 tomato varieties

Power	Concentration ratio (%)	LYCOPENE (mg/100) GMS	LYCOPENE (mg/100) SMILK	LYCOPENE (mg/100) GMS	LYCOPENE (mg/100) SMILK
		Kerewa		UC-82B	
230	0.01	2.74	2.84	2.83	4.64
230	0.02	1.54	5.51	2.47	4.53
230	0.03	2.89	4.13	2.99	4.39
385	0.01	3.14	2.84	1.45	5.01
385	0.02	1.32	4.99	1.28	4.86
385	0.03	1.95	4.42	1.36	4.13
540	0.01	5.03	6.61	5.14	2.91
540	0.02	4.21	3.39	5.01	2.98
540	0.03	5.19	2.71	5.21	2.89

Similar observation can be seen for the UC-82B variety as presented in Table 1 with values varied between 1.28 to 5.41(mg/100) for skimmed milk and 2.89 to 5.01 (mg/100) for skimmed milk. However, content levels of UC-82B were always greater than corresponding values of Kerewa variety. Consequently, the lycopene contents of the UC-82B varieties are higher than Kerewa variety. The significance of this observation is that reduction in lycopene content from the raw value was minimal with the skimmed milk as the foaming agent.

The change in lycopene content is expected due to the labile nature of lycopene to heat as observed by Kadam et al. (2012). The effect of power on lycopene content was more obvious at the highest microwave power where the contents of GMS dried tomato appear to have higher values. This might indicate a possible interaction between the high heating temperatures (about 80^{O}C) and foaming agent. The constituents of the skimmed milk may have degradation at higher temperature affecting the foaming property of the foaming agent.

It was noticed that the lycopene content at different foaming agent concentration level within any particular power level were slightly different. However, this change appears to be fluctuated, further analysis showed that there was no significant differences in the values of lycopene contents at different concentration levels as depicted in the response plot shown in Fig 1.

The non-significant effect of concentration levels is in consonance with previous research of Athanasia *et al* (2005), in tomato spray drying, Takeoka *et al.* (2001) in tomato processing and Kadam *et. al* (2012).

Effect of foaming agent and concentration level on Ascorbic acid Contents of Kerewa and UC-82B tomato varieties

Ascorbic acid content of reconstituted foam mat dried tomato powder ranges between 1.75 to 4.04mg/100 mg as presented in Tables 2 for both UC-82B and Kerewa tomato varieties.

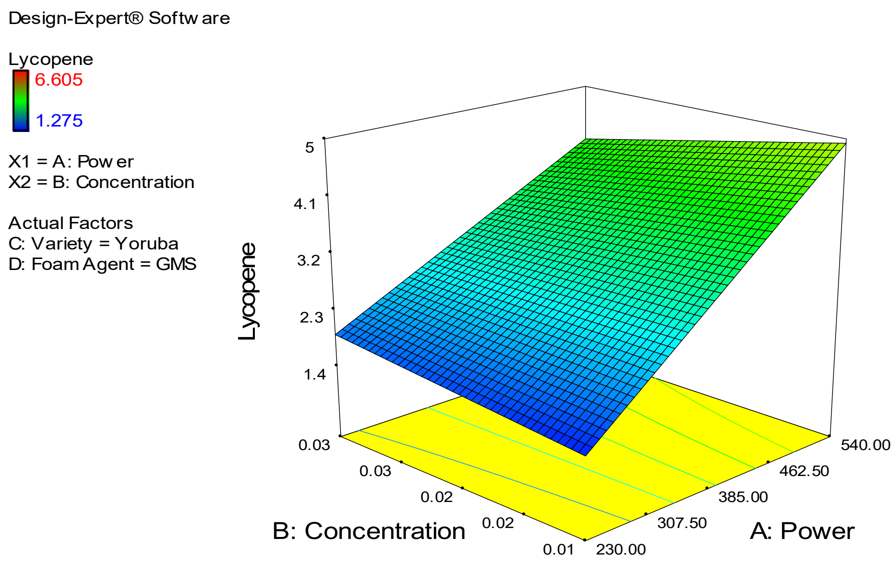

Fig 1: Response surface of lycopene as affected by concentration level and power.

Table 2. Effect of foaming agent and concentration level on Ascorbic Acid contents of Kerewa and UC-82 tomato varieties

Power	Concentration ratio (%)	ASCORBIC ACID (mg/100) GMS	ASCORBIC ACID (mg/100) SMILK	ASCORBIC ACID (mg/100) GMS	ASCORBIC ACID (mg/100) SMILK
		Kerewa		UC-82B	
230	0.01	2.26	2.36	2.27	2.43
230	0.02	3.15	2.38	2.57	2.49
230	0.03	2.32	3.25	2.30	2.38
385	0.01	2.54	2.79	1.75	2.37
385	0.02	1.99	2.12	1.85	2.01
385	0.03	1.93	3.29	1.89	2.41
540	0.01	3.74	2.45	3.81	2.54
540	0.02	3.66	2.39	3.52	2.40
540	0.03	4.04	2.59	3.92	2.57

For both varieties, there was a reduction in ascorbic acid content from 230-microwave power to 385W microwave power, however after this at 540W power there was an increase in ascorbic acid content. The trend for increase in ascorbic with power was curvilinear as indicating that increased temperature due to high heating power might have serious effect on the ascorbic acid reduction. The decrease in ascorbic acid content of foam mat dried tomato powder could be due to its heat sensitive nature.

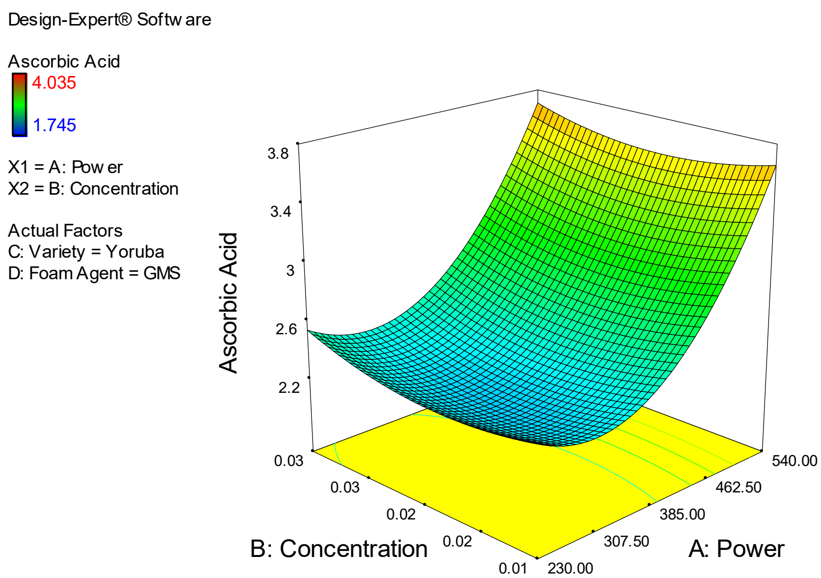

Fig 2: Response surface of ascorbic acid as affected by concentration level and power.

Similar decline in ascorbic acid content was reported in other vegetables including potato, pulses, muskmelon and onion following heat treatment (Kadam *et. al.,* 2019). There was no significant variation with increasing concentration of the foaming agent as observed in the response surface plot of Fig 2, however, power had a more significant role in the ascorbic acid content for all the foaming agents used in the study. Similar observation was reported by Kadam *et, al*. (2012).

Effect of foaming agent and concentration level on Color change and Rehydration ratio of Kerewa and UC-82B tomato varieties

The effects of various concentration level of foaming agent (Skimmed milk and GMS) on colour change associated with kerewa and UC-82B tomato varieties are presented in Table 3 There was a change in the color of the dried tomato powder as compared to the raw tomato in which according to standard the change in color should not be > than 3. All the power levels had colour change greater than 3 for all the foaming agents and the various concentration levels. There was a more change due to power than was observed for concentration level as shown in the response plot of Fig 3. This is an indication that microwave power had a more significant effect on colour change than concentration level and that skimmed milk showed a higher change than the GMS. Since a minimal change would be required for quality assurance, the GMS would be a preferable foaming agent in terms of colour change while power levels must not be greater than 385W.

Results for rehydration ratio values for both Kerewa and UC-82B tomato varieties after reconstitution showed that there were only slight differences in their values at different power levels and foaming agents. The concentration of foaming agent also appears not to have significantly affected the rehydration ratio. The implication of this observation is that any of the microwave heating power levels could be selected as well as foaming agent and concentration levels. This implies that the rehydration level may not be a serious factor in selection of the best operating parameters in foam mat drying.

Table 3. Effect of foaming agent and concentration level on Colour change ΔE of Kerewa and UC-82B tomato variety

Power	Concentration Ratio (%)	GMS	SMILK	GMS	SMILK
		Kerewa		UC-82B	
230	0.01	4.50	4.05	6.85	7.51
230	0.02	4.52	3.96	6.97	7.54
230	0.03	4.66	4.76	7.11	7.75
385	0.01	5.82	5.24	7.40	7.02
385	0.02	3.84	4.09	7.18	7.35
385	0.03	4.29	3.14	7.37	7.98
540	0.01	4.26	4.36	7.40	7.06
540	0.02	5.83	3.97	7.38	7.22
540	0.03	5.64	4.64	7.29	7.16

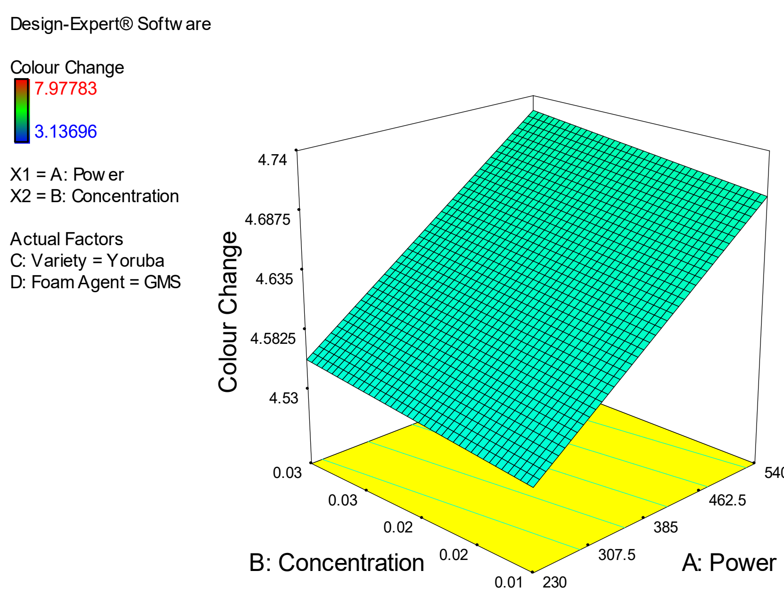

Fig 3: Response surface of colour change as affected by power and concentration level

A typical comparison graph for the selected properties for Kerewa and UC-82B varieties at a microwave heating power of 230W is shown in Fig 4.

CONCLUSION

Tomato powder was produced using Glycerol Monostrate (GMS) and Skimmed milk as forming agents and Carboxyl Methyl Cellulose (CMC) as a stabilizer for Kerewa and UC-82B tomato varieties.

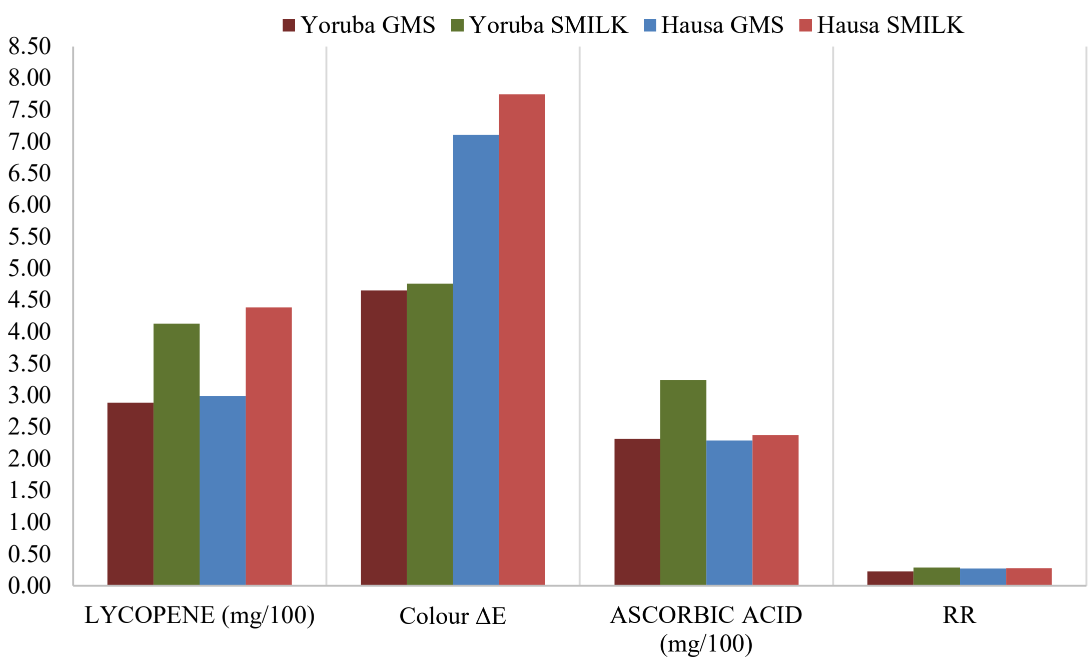

Fig 4. Effect of foaming agent on properties of Hausa and yoruba tomato varieties dried at microwave power of 230W

The color change was affected by all factors with UC-82B variety having the maximum color change, indicating that Kerewa variety would be preferable in terms of colour.

Rehydration ratio was constant for all levels of factors considered and for both varieties of tomato used and may not be a better criterion for evaluation. Concentration levels of foaming agents did not appreciably affect the nutritional and physical quantities considered for both Kerewa and UC- 82B varieties.

Microwave power levels affected the color change and ascorbic acid content of the finished product. There was an increased level of Color change and reduction in Ascorbic acid with increased power level. A power level greater than 348W may not be recommended.

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