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Optimization of microwave drying conditions of two banana varieties using response surface methodology

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Abstract

Optimization of microwave drying conditions of *Luvhele* and *Mabonde* banana varieties were studied using response surface methodology. The drying was performed using a central composite rotatable design for two variables: microwave power level (100, 200 and 300 W) and drying time (40, 26, and 12 min.) for *Luvhele*; (100, 200 and 300 W) and (42, 27, and 12 min) for *Mabonde*. The colour and texture (hardness) data were analyzed using ANOVA and regression analysis. The fitness of the models obtained was good as the lack of fit for each of the models was not significant. The coefficient of determination R^2 of the models was relatively high, hence the models obtained for the responses were adequate and acceptable. Drying conditions of 178.76 W, 12 min. drying time were found optimum for product quality at a desirability of 0.91 for *Luvhele*; while 127.67 W, 12 min. with a desirability of 0.86 was predicted for *Mabonde*. The result of this study could be used as a standard for microwave processing of *Luvhele* and *Mabonde* banana varieties.

Keywords: banana; *Luvhele*; *Mabonde;* microwave; drying; response surface methodology; colour; hardness; models; optimization.

Practical Application: Drying refers to the removal of moisture from a material with the primary aim of reducing microbial activity and product deterioration. Drying of agricultural products offer other advantages such as reduced packaging, handling, storage and transportation costs. Microwave drying has advantages of high drying rates, high energy efficiency, better product quality and efficient space utilization. Response surface methodology has important application in the design, development and formulation of new products, as well as in the improvement of existing product design.

1 Introduction

Response surface methodology (RSM) is a collection of statistical and mathematical techniques useful for developing, improving, and optimizing processes in which a response of interest is influenced by several variables and the objective is to optimize this response. RSM has important application in the design, development and formulation of new products, as well as in the improvement of existing product design. It defines the effect of the independent variables, alone or in combination, on the processes. In addition to analyzing the effects of the independent variables, this experimental methodology generates a mathematical model which describes the chemical or biochemical processes (Anjum et al., 1997; Myers & Montgomery, 1995). Before applying the RSM methodology, it is first necessary to choose an experimental design that will define which experiments should be carried out in the experimental region being studied. There are some experimental matrices for this purpose (Bezerra et al., 2008). Some examples of the RSM applications performed for optimization of food processes include optimization of *fura* production, processing parameter optimization for obtaining dry beans with reduced cooking time, optimization of edible oil extraction from *ofada* rice bran and optimization of microwave-assisted hot-air drying conditions of okra (Jideani et al., 2010; Akinoso & Adeyanju 2012; Schoeninger et al., 2014; Kumar et al., 2014).

Microwave drying has advantages of high drying rates, high energy efficiency, better product quality and efficient space utilization (Sutar & Prasad, 2007; Dadali et al., 2007a, b; Wang & Sheng, 2006; Maskan, 2000). Microwave heating is a result of dipolar interaction of water molecules inside the food material. The polar water molecules tend to align themselves according to changing electric field and heat is produced due to friction between oscillating molecules. This rapid internal heat generation causes the pressure build up and results in rapid evaporation of water (Datta & Anantheswaran, 2001; Prabhanjan et al., 1995).

Luvhele and *Mabonde* varieties are bananas grown in South Africa. They are rich in nutrients and antioxidants (Anyasi et al., 2015). Recent studies on these banana varieties include the effect of organic acid pre-treatment on some physical, functional and antioxidant properties of flour obtained from these banana varieties (Anyasi et al., 2015); microwave drying kinetics of *Luvhele* banana variety (Omolola et al., 2014a) and modeling microwave drying kinetics and moisture diffusivity of *Mabonde* banana variety (Omolola et al., 2014b). At present there is no specific standard developed for determining the quality of the banana varieties. The standardization of the drying process of the banana varieties therefore becomes important in order to

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obtain the optimum drying conditions, for optimum product in terms of quality. Thus, the aim of this work is to study the effect of microwave power and drying time on colour and texture (hardness) of *Luvhele* and *Mabonde* banana varieties under microwave-drying process using response surface methodology.

2 Materials and methods

2.1 Source and preparation of banana sample

Bananas of the varieties "*Luvhele* and *Mabonde*" (Musa species) procured from a farm in Limpopo province of South Africa were used in the study. The ripe fruits had a peel colour index of 7, which is associated with the maximum sucrose content and completely yellow skin with small brownish speckles (Sousa & Marsaioli, 2004). The bananas fingers were cleaned, washed, peeled and sliced manually into a thickness of 5 mm. The sliced portions were treated with 4% (w/v) citric acid solution for 10 min.

2.2 Drying experiment

The drying experiment was carried out in a domestic microwave oven (model P70B17L-T8) with technical features of 220-240 V, 50 Hz and 700 W at the frequency of 2450 MHz. The dimensions of the microwave cavity were 262 × 452 × 335 mm equipped with a glass turn table of 320 mm diameter and a control facility to monitor the microwave output and processing during drying operation (Ganesapillai et al., 2011; Silva et al., 2014). Drying was conducted in triplicate according to the central composite design with two independent variables (microwave power and drying time) as shown in as shown in Tables 1 for *Luvhele* and 3 for *Mabonde*. The codes and levels of independent variables used for generating experimental runs for this study are given in Table 2.

2.3 Colour determination

The surface colour of dried banana slices was measured using a colorimeter (ColorFlex, HunterLab, USA). The colorimeter was calibrated with a standard white (L* = 93.71, a* = –0.84 and b* = 1.83) and black plate before each color measurement. The colours were expressed as L-value (lightness/darkness), a-value (redness/greenness) and b-value (yellowness/blueness). The overall color of dried banana slices was reported using hue angle (Thuwapanichayanan et al., 2011), which was calculated by the Equation 1:

$$\text{Hue} = \tan^{-1}(b/a) \quad (1)$$

The measurements were performed in triplicate and the average values were reported.

Table 1. Levels of process variables and values of quality parameters for *Luvhele* banana variety dried under microwave-drying conditions.

S/N	Independent variables		Response variables				Hardness (N)
	Power (W)	Time (min.)	L*	a*	b*	°Hue	
1	100	12	44.59 ± 0.05	11.83 ± 0.02	33.51 ± 0.13	70.55 ± 0.05	1.61 ± 0.05
2	200	6.2	46.96 ± 0.05	9.29 ± 0.01	33.6 ± 0.16	74.54 ± 0.05	1.29 ± 0.05
3	200	45.8	45.88 ± 0.05	13.84 ± 0.14	33.49 ± 0.32	67.51 ± 0.05	9.99 ± 0.05
4	300	40	42.8 ± 0.05	17.54 ± 0.02	33.17 ± 0.11	62.14 ± 0.05	2.92 ± 0.05
5	200	26	50.32 ± 0.05	9.13 ± 0.07	34.57 ± 0.39	75.21 ± 0.05	1.39 ± 0.05
6	341.42	26	45.28 ± 0.05	13.97 ± 0.3	34.51 ± 0.82	67.96 ± 0.05	14.28 ± 0.05
7	100	40	54.48 ± 0.05	10.67 ± 0.06	39.68 ± 0.37	74.95 ± 0.05	4.07 ± 0.01
8	100	40	51.47 ± 0.05	12.26 ± 0.05	38.4 ± 0.28	72.29 ± 0.05	3.62 ± 0.05
9	300	12	41.55 ± 0.05	17.54 ± 0.07	32.83 ± 0.21	61.88 ± 0.05	8.11 ± 0.05
10	300	40	45.75 ± 0.05	13.79 ± 0.11	33.68 ± 0.29	67.73 ± 0.03	2.87 ± 0.03
11	300	12	37.58 ± 0.05	17.63 ± 0.14	32.15 ± 0.26	61.25 ± 0.03	8.41 ± 0.03
12	58.58	26	49.51 ± 0.05	10.64 ± 0.04	36.69 ± 0.24	73.84 ± 0.04	3.84 ± 0.03
13	200	6.2	42.4 ± 0.05	10.43 ± 0.17	29.48 ± 0.34	70.73 ± 0.4	1.79 ± 0.03
14	100	12	47.54 ± 0.05	10.24 ± 0.01	33.42 ± 0.10	72.96 ± 0.03	1.41 ± 0.03
15	341.42	26	45.35 ± 0.05	15.18 ± 0.38	33.6 ± 0.90	65.69 ± 0.03	13.23 ± 0.03
16	200	45.8	39.33 ± 0.4	14.11 ± 0.15	28.66 ± 0.34	63.79 ± 0.03	8.63 ± 0.03
17	58.58	26	46.15 ± 0.05	11.65 ± 0.07	35.54 ± 0.28	71.85 ± 0.03	3.72 ± 0.03
18	200	26	43.11 ± 0.05	10.59 ± 0.13	30.28 ± 0.43	70.72 ± 0.03	1.41 ± 0.03
19	200	26	47.61 ± 0.05	9.08 ± 0.19	33.27 ± 0.42	74.95 ± 0.03	1.66 ± 0.03

Table 2. Levels of independent variables used for central composite rotatable design.

Banana variety	Code	Microwave power (W)	Drying time (min.)
	–1	100	40
Luvhele	0	200	26
	1	300	12
	–1	100	42
Mabonde	0	200	27
	1	300	12

2.4 Texture (hardness) determination

Textural attributes of dried banana slices were measured using a texture analyzer TA.XT PLUS, Stable Micro Systems fitted with a 5-N load cell equipped with a 35 mm flat ended cylindrical aluminum body. The flat ended cylindrical aluminum body moved down vertically with a velocity of 2 mm/s and compressed the sample slice placed on the base. The maximum compression force in the force–deformation curve of each sample was considered as an indication of the hardness of the sample (Kotwaliwale et al., 2007; Kumar et al., 2014). The measurements were performed in triplicate and the average values (± SD) were reported.

2.5 Statistical analysis

All the experimental procedures were carried out in triplicate and values recorded as mean ± standard deviation. Collected data were processed using a commercial statistical package, Design-Expert Version 8.0.1.0 (Statease Inc; Minneapolis USA, version). The software was used for analysis of variance (ANOVA), regression analysis, and optimization (Akinoso & Adeyanju, 2012). The response surface plots were generated for different interactions. The numerical optimization of the drying process was aimed at finding the levels of microwave power and drying time, which could maximize the overall colour (hue) and minimize hardness.

3 Results and discussions

3.1 Colour characteristics of Luvhele and Mabonde banana varieties under microwave-drying process

The colour characteristics of the two banana varieties varied with microwave power and drying time. The range of L*, a *, and b* of *Luvhele* were 37.58 to 54.48, 9.08 to 17.63, and 28.66 to 39.68 respectively (Table 1) while L*, a*, and b* values for *Mabonde* were in the range of 40.29 to 50.27, 11.18 to 17.12, 29.15 to 41.75 (Table 3). These variations in the values of the colour parameters, at different drying conditions can be attributed to chemical changes in the colour pigment of the banana varieties due to heat and oxidation during drying. The overall colour change of the dried banana slices was determined in terms of hue angle (Tables 1 and 3). A larger value of hue angle indicate a greater shift from red to yellow (Thuwapanichayanan et al., 2011). ANOVA of the effect of model parameters on colour characteristics of *Luvhele* and *Mabonde* showed that linear effects of microwave power and drying time, interaction effects of microwave power and drying time, quadratic effects of microwave power and drying time, all had significant ($p < 0.05$) effects on the colour parameters L*, a*, b* and the hue of the banana varieties (Tables 4 and 5).

Regression models relating L*, a*, b* and hue to the independent variables, that is, microwave power and drying time for *Luvhele* and *Mabonde* are shown in Tables 6 and 7 respectively. Table 6 shows that the linear model best explains the relationship between the processing variables and L*, a*, b* and hue for *Luvhele*. In terms of *Mabonde,* quadratic, linear, reduced quadratic and quadratic models best explain the relationship between the processing variables and L*, a*, b* and hue respectively for *Mabonde* (Table 7). A lack of fit test of the models was non-significant ($p > 0.05$). Non-significant lack of fit is good as this strengthens the fitness of the models. Coefficient of determination (R^2) of models was relatively high. This guarantees a good fitness of the models when applied. The coefficients of the models parameters indicate the magnitude and significance of each model parameter with regards to their effects on the response variables, that is, the higher the coefficient of a model parameter, the higher the significance of such parameter (Jideani et al., 2010). For *Luvhele* drying time

Table 3. Levels of process variables and values of quality parameters for *Mabonde* banana variety dried under microwave-drying conditions.

S/N	Independent variables		Response variables				Hardness (N)
	Power (W)	Time (min.)	L*	a*	b*	°Hue	
1	300	12	43.47 ± 0.05	15.24 ± 0.25	31.44 ± 0.59	64.14 ± 0.05	6.36 ± 0.05
2	200	27	46.08 ± 0.06	14.49 ± 0.16	37.46 ± 0.50	68.85 ± 0.05	3.56 ± 0.05
3	300	42	43.53 ± 0.05	17.12 ± 0.28	32.45 ± 0.58	62.19 ± 0.05	2.77 ± 0.05
4	58.58	27	46.41 ± 0.02	13.47 ± 0.14	38.05 ± 0.58	70.48 ± 0.05	0.87 ± 0.05
5	100	42	44.81 ± 0.05	11.18 ± 0.07	33.42 ± 0.32	71.51± 0.05	0.45 ± 0.03
6	100	42	42.88 ± 0.05	13.5 ± 0.01	33.94 ± 0.11	68.3 ± 0.05	2.39 ± 0.05
7	100	12	41.85 ± 0.08	11.41 ± 0.11	31 ± 0.40	69.79 ± 0.05	0.57 ± 0.05
8	58.58	27	44.83 ± 0.06	13.06 ± 0.27	35.81 ± 0.83	69.96 ± 0.05	1.14 ± 0.05
9	300	12	47.4 ± 0.05	14.91 ± 0.12	33.56 ± 0.35	66.04 ± 0.05	9.28 ± 0.05
10	200	5.79	49.13 ± 0.05	12.34 ± 0.06	39.18 ± 0.34	72.51 ± 0.05	0.73 ± 0.05
11	200	5.79	47.92 ± 0.05	12.42 ± 0.23	37.38 ± 0.21	71.46 ± 0.05	0.73 ± 0.02
12	200	27	47.9 ± 0.05	15.64 ± 0.26	39.19 ± 0.76	68.25 ± 0.05	4.04 ± 0.05
13	200	27	46.44 ± 0.32	14.19 ± 0.26	37.93 ± 0.74	69.49 ± 0.02	2.22 ± 0.05
14	100	12	45.49 ± 0.02	12.29 ± 0.16	34.78 ± 0.38	70.53 ± 0.05	1.38 ± 0.05
15	200	48.21	48.78 ± 0.05	16.02 ± 0.04	40.74 ± 0.25	68.5 ± 0.05	8.36 ± 0.05
16	341.42	27	46.77 ± 0.05	16.08 ± 0.15	34.45 ± 0.40	64.98 ± 0.05	6.35 ± 0.03
17	300	42	40.29 ± 0.04	16.81 ± 0.02	29.15 ± 0.02	60.03 ± 0.03	5.64 ± 0.03
18	341.42	27	42.77 ± 0.05	16.22 ± 1.04	31.81 ± 0.27	63.93 ± 0.03	3.96 ± 0.03
19	200	48.21	50.27 ± 0.05	15.79 ± 0.18	41.75 ± 0.52	69.27 ± 0.03	5.65 ± 0.03

Table 4. ANOVA results of the effect of model parameters on colour characteristics and texture of *Luvhele* banana variety.

Source	L*		a*		b*		°Hue		Hardness	
	F- Value	P - Value	F- Value	P - Value	F- Value	P - Value	F- Value	P - Value	F- Value	P – Value
Model	8.44	0.0035*	12.74	0.0014*	21.84	0.0001*	7.53	0.0036*	56.63	<0.0001*
A-Power	*10.62*	*0.0053**	*25.33*	*0.0004**	*27.13*	*0.0004**	*6.16*	*0.0275**	*96.01*	*<0.0001**
B-Time	*6.26*	*0.0244**	*0.15*	*0.7074*	*25.46*	*0.0005**	*7.12*	*0.0193**	*12.46*	*0.0064**
AB					*12.93*	*0.0049**	*4.55*	*0.0526*	*29.64*	*118.2*
A^2									*32.14*	*128.15*
B^2									*0.1*	*0.4*

*Significant at $p < 0.05$. *A*- linear effect of microwave power; *B*- linear effect of drying time; *AB*- interaction of microwave power and drying time; A^2 quadratic effect of microwave power; B^2- quadratic effect of drying time; L*- (lightness/darkness); a*- (redness/greenness) and b*- (yellowness/blueness).

Table 5. ANOVA results of the effect of model parameters on colour characteristics and texture of *Mabonde* banana variety.

	L*		a*		b*		°Hue		Hardness	
	F- Value	P - Value	F- Value	P - Value	F- Value	P - Value	F- Value	P - Value	F- Value	P - Value
Model	11.93	0.0045*	77.26	<0.0001*	12.98	0.0014*	43.43	<0.0001*	36.27	<0.0001*
A-Power	*1.77*	*0.2315*	*82.48*	*<0.0001**	*8.2*	*0.021**	*126.09*	*<0.0001**	*23.19*	*0.0007**
B-Time	*1.13*	*0.3285*	*61.23*	*<0.0001**	*4.99*	*0.0559*	*29.69*	*0.0006**	*37.12*	*0.0001**
AB	*36.17*	*0.001**			*22.31*	*0.0015**	*20.81*	*0.0018**		
A^2	*0.59*	*0.473*			*23.84*	*0.0012**	*13.18*	*0.0067**	*1.33*	
B^2	*10.08*	*0.0192**					*13.36*	*0.0065**		

*Significant at $p < 0.05$. *A*- linear effect of microwave power; *B*- linear effect of drying time; *AB* - interaction of microwave power and drying time; A^2- quadratic effect of microwave power; B^2- quadratic effect of drying time; L*- (lightness/darkness); a*- (redness/greenness) and b*- (yellowness/blueness).

Table 6. Regression models relating response and independent variables for *Luvhele* banana variety.

Response variables	Models	Residual lack of fit *p* – value	R^2
L*	+ 47.27177 - 0.023446**A* + 0.13798**B*	0.3035*	0.53
a*	+ 10.09847 + 0.019501**A* - 0.012615**B*	0.1357*	0.69
b*	+ 29.68903 + 9.66376E-003**A* + 0.28196**B* - 8.28571E-004**A** *B*	0.0621*	0.87
°Hue	+ 68.77147 + 0.029205**A* + 0.22492* *B* - 1.86545E-003*A**B*	0.2198*	0.64
Hardness	+1.84062 - 0.049568**A* + 0.27099**B* - 1.37500E-003**A***B* + 2.53866E - 004**A2* - 7.25924E-004**B2*	0.3002*	0.97

*Non-significant ($p > 0.05$). *A* - linear effect of microwave power; *B* - linear effect of drying time; *AB* - interaction of microwave power and drying time; A^2 - quadratic effect of microwave power; B^2 - quadratic effect of drying time; L*- (lightness/darkness); a*- (redness/greenness) and b*- (yellowness/blueness).

Table 7. Regression models relating response and independent variables for *Mabonde* banana variety.

Response variables	Models	Residual lack of fit *p* - value	R^2
L*	+63.74882 - 0.063736**A* - 0.83820**B* + 2.96544E-003**A***B*- 2.92672E-005**A2* + 4.92963E-003**B2*	0.7981*	0.91
a*	+9.88953 + 0.012956*A + 0.074421**B*	0.1242*	0.91
b*	+52.54853 - 0.036127**A* - 0.69969**B* + 3.84786E - 003**A***B* -2.03000E-004**A2*	0.127*	0.87
°Hue	+67.86640 + 0.042872*A - 0.020998*B - 1.19261E-003*A*B-7.71865E-005**A2* + 3.45282E-003*B^2	0.8573*	0.97
Hardness	-1.81639 + 0.011451**A* + 0.092879**B*	0.3809*	0.88

*Non-significant ($p > 0.05$). *A*- linear effect of microwave power; *B*- linear effect of drying time; *AB* - interaction of microwave power and drying time; A^2 - quadratic effect of microwave power; B^2 - quadratic effect of drying time; L*- (lightness/darkness); a*- (redness/greenness) and b*- (yellowness/blueness).

(B) had the most linear effect on L*, b*, and hue angle while microwave power (A) had the most linear effect on a* (Table 6). In terms of *Mabonde*, drying time (B) had the most quadratic, linear and quadratic effect on L*, a,* and hue respectively while the interactive effect of microwave power and drying time (AB) had the most significant on b* (Table 7).

Response surface plots of the variability of L*, a*, b* and hue angle with change in microwave power levels, and drying time for *Luvhele* and *Mabonde* banana varieties are shown in Figures 1, 2 and 3. Akinoso & Adeyanju (2012) reported that response surface plot helps to visualize the shape of the response surface and give useful information about model fitness. It is

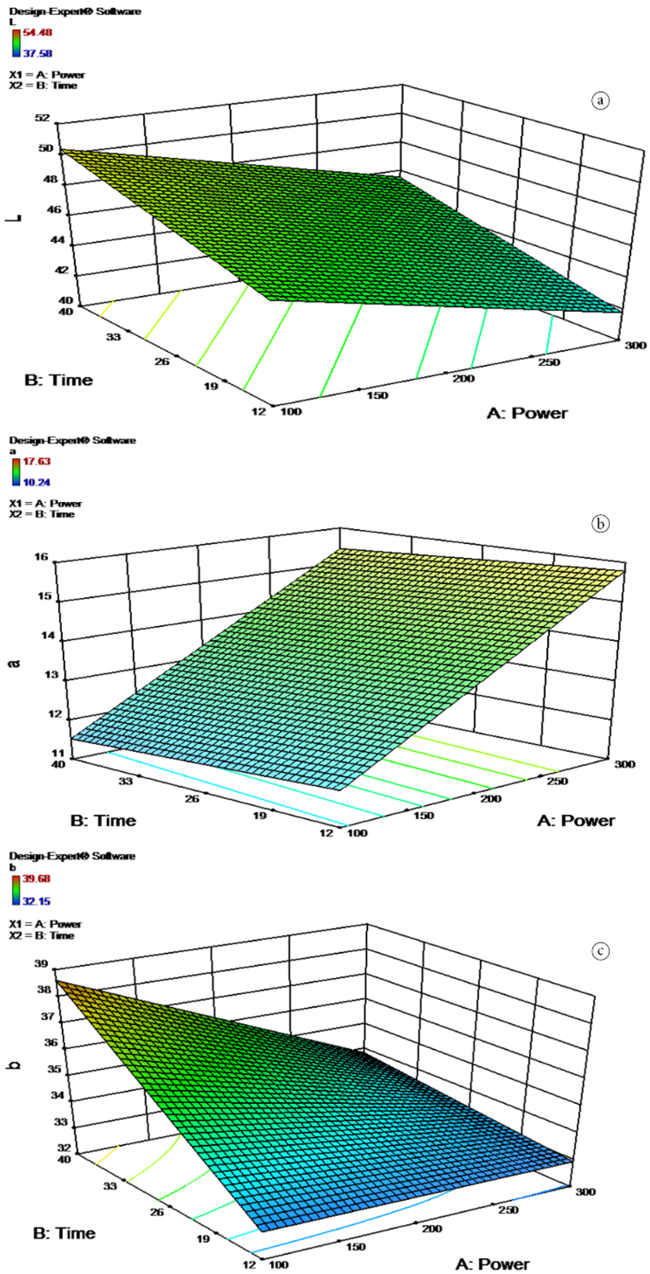

Figure 1. Response surface plot for the effects of microwave power and drying time on lightness (L*) (a), redness (a*) (b) and yellowness (b*) (c) of *Luvhele* banana variety.

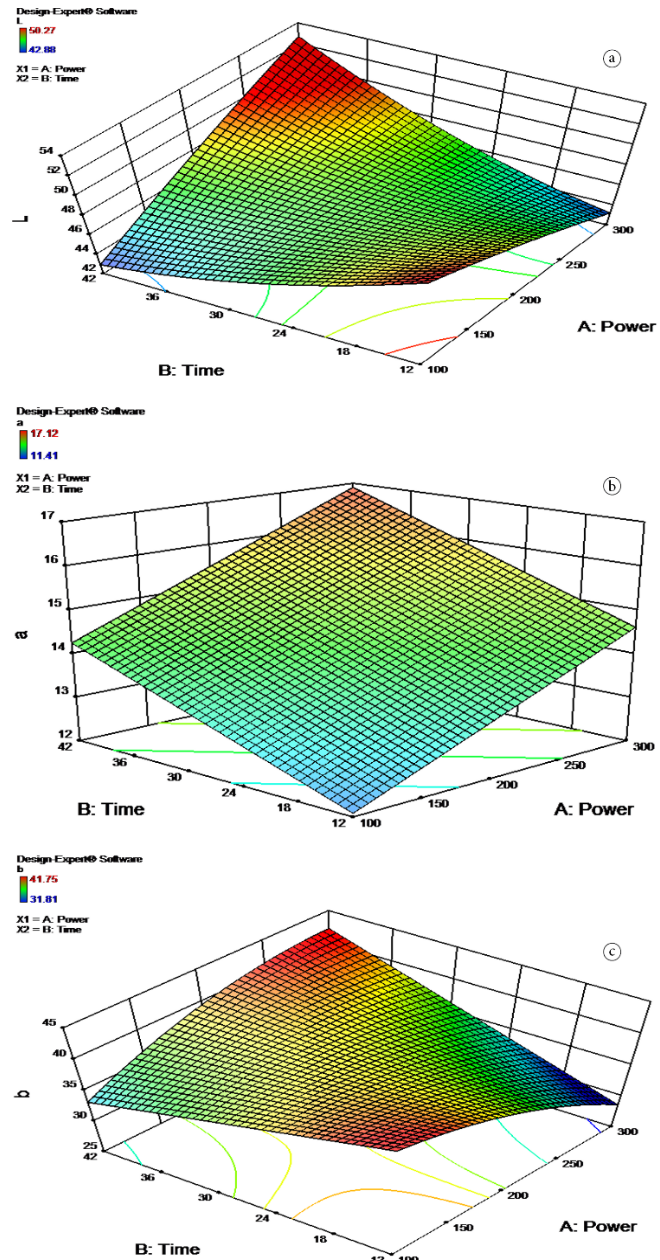

Figure 2. Response surface plot for the effects of microwave power and drying time on lightness (L*) (a), redness (a*) (b) and yellowness (b*) (c) of *Mabonde* banana variety.

evident from the figures that there are differences in the shape of the response surface plots obtained for *Luvhele* and *Mabonde*. These differences can be attributed to the effect of banana variety and processing conditions.

3.2 Hardness of Luvhele and Mabonde under microwave drying process

Hardness of *Luvhele* and *Mabonde* banana dried under various drying conditions ranged between 1.29 to 14.28 N and 0.45 to 9.28 N. The highest value of hardness was obtained at 341.42 W microwave power 26 min drying time for *Luvhele* (Table 2) and 300 W microwave power 12 min drying time for *Mabonde* (Table 3). ANOVA showed that microwave power, drying time, interaction of microwave power and drying time and quadratic effect of microwave power had significant effect ($p < 0.05$) on hardness of *Luvhele* (Table 4) while microwave power and drying time had significant effect on hardness of *Mabonde* (Table 5). Regression models relating hardness to the independent variables obtained for *Luvhele* (Table 6) and *Mabonde* (Table 7) satisfied the lack of fit test ($p > 0.05$) with a coefficient of determination R^2 as high as 0.97 (*Luvhele*) and 0.88 (*Mabonde*), hence the models can be used to explain the functional relationship between microwave power, drying time

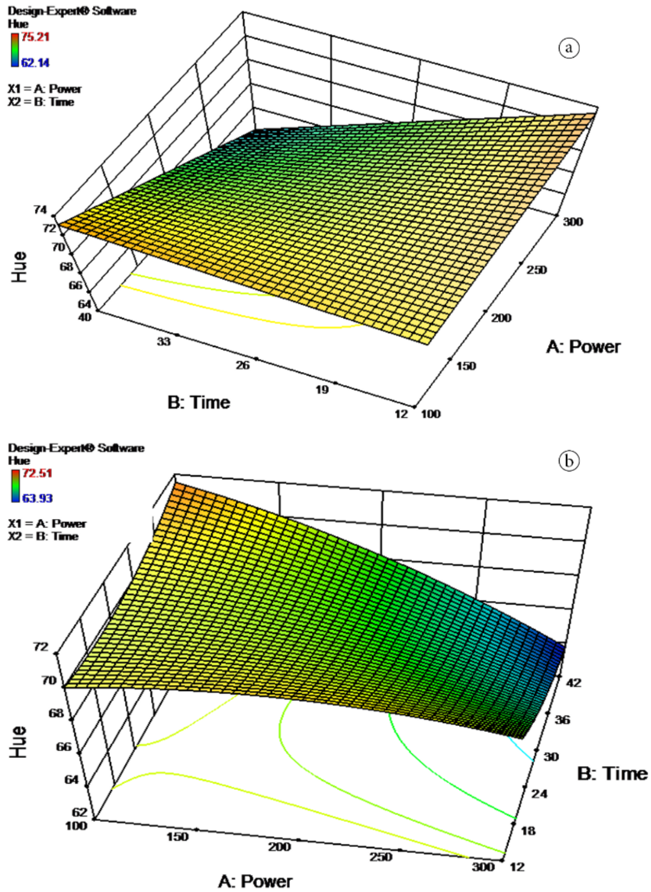

Figure 3. Response surface plot for the effects of microwave power and drying time on the hue of *Luvhele* (a) and *Mabonde* (b) banana varieties.

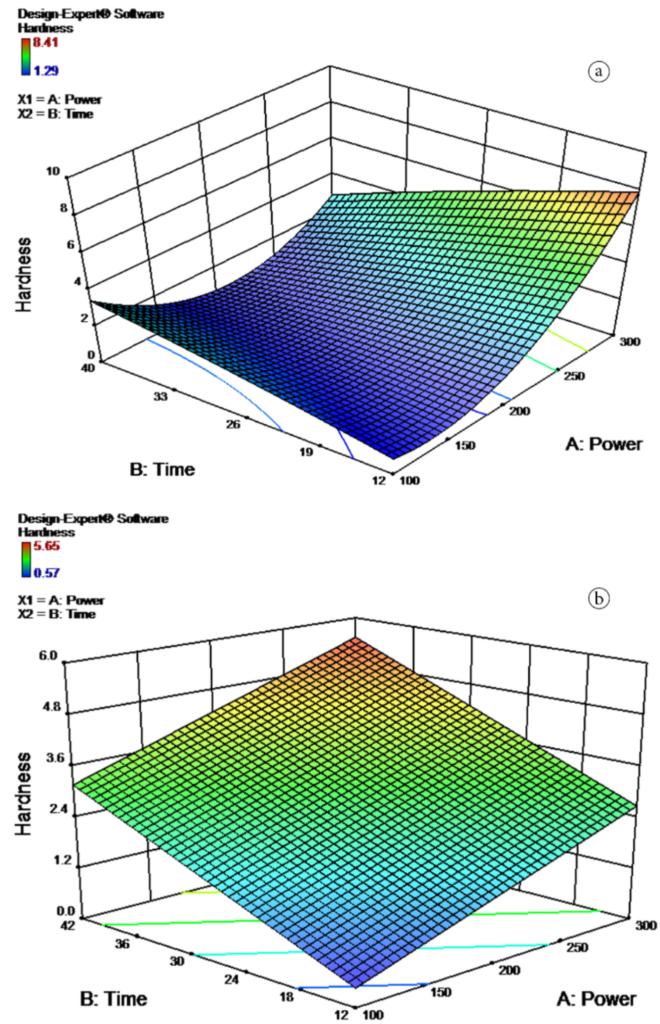

Figure 4. Response surface plot for the effects of microwave power and drying time on hardness of *Luvhele* (a) and *Mabonde* (b) banana varieties.

and hardness. The Tables further showed that linear effect of drying time had the most significant effect on hardness of *Luvhele* (Table 6) and *Mabonde* (Table 7). The variability of microwave power level and drying time on hardness of *Luvhele* (Figure 4a) and *Mabonde* (Figure 4b) showed that hardness increased with increase in microwave power for the two banana varieties. This might be due to crystallisation of cellulose and localised variations in the moisture content of the banana varieties during drying, as a result of the high internal pressure development at high microwave power levels, which sest up internal stresses and caused collapse of capillary spaces inside the samples (Fellows, 2009; Kotwaliwale et al., 2007).

3.3 Optimization and validation of microwave drying of Luvhele and Mabonde

The results of optimization of drying conditions for *Luvhele* was 178.76 W microwave power, 12 min drying duration and 127.67 W microwave power, 12 min drying duration for *Mabonde*. The predicted values of colour (hue) and hardness at the optimized conditions were 72.68° and 1 N for *Luvhele* while 70° and 0.86 N were obtained for *Mabonde*. Desirability of the obtained optimum conditions were 0.91 and 0.86 for *Luvhele* and *Mabonde* respectively. The indication of this result is that drying of *Luvhele* and *Mabonde* at the optimized drying conditions will increase energy savings and yield dried samples with good quality in terms of colour and hardness. Validation of the software generated optimum drying conditions for the banana varieties was achieved by experimentally subjecting the banana slices to the optimized drying conditions obtained by RSM. The experimental values of hue and hardness were 72.64° and 1.05 N for *Luvhele* and 70.07° and 0.89 N for *Mabonde*. These values are relatively close to the software generated values, hence confirming the validity of the optimized results and consistency of the regression models generated by the RSM software. Food processing industries can therefore use the optimized drying conditions as a standard or base line information for industrial processing of the banana varieties.

4 Conclusion

Regression models were developed to effectively predict quality parameters at any given microwave power and drying time. Good fit of the models were justified with the non-significant lack of fit ($p > 0.05$) and relatively high regression values. The drying conditions of 178.76 W microwave power, 12 min. drying time were found optimum for product quality at a desirability of 0.91 for *Luvhele* while 127.67 W microwave power, 12 min drying duration with a desirability of 0.86 was predicted for *Mabonde*. Response surface methodology was effective in optimizing process parameters for microwave drying of *Luvhele* and *Mabonde* banana varieties. Hence the optimum drying conditions obtained in this study could be used as a standard or base line information for industrial processing of the banana varieties.

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