Development of Microwave Baked Potato Chips using Tomato Flavour

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ABSTRACT— ***The present investigation is to study the development of microwave baked potato chips using tomato flavour. Response surface methodology was used to investigate the optimum operation conditions of a microwave baked tomato flavored potato chips and to analyze the effects of microwave baking processing variables, including dehydration time (60-180min), microwave power (20-100 watts), baking time (10-50sec) and potato slices thickness 2 mm (constant). Quadratic polynomial equations were also obtained by multiple regression analysis. The predicted models were adequate based on the lack-of-fit test and coefficient of determination obtained. By superimposing individual contour plots of the different responses, regions meeting the optimum conditions were also derived. Quadratic regression equations describing the effects of these factors on the physico-chemical attributes were developed. It was found that effects of dehydration time and microwave power were more significant on the moisture& fat content than baking time. As for protein and ash content the dehydration time, microwave power & baking time were the most significant factors. The microwave baking process was optimized for physico-chemical attributes. The optimum conditions were found to be: dehydration time 151.20 min, microwave power 61.99 watts and baking time 50 sec.˙At this condition the optimum values of protein, fat, moisture and ash content were found to be 4.583%, 0.333%, 3.864% & 3.897% respectively.***

Keywords— Microwave baking, potato chips, tomato flavour, response surface methodology.

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1. INTRODUCTION

Potato (Solanum tuberos) is a starchy, tuberous crop of the Solanaceae and one of the world's major crops, is consumed daily by millions of people from diverse cultural backgrounds (Pedrschi et al., 2005; Lechman et al., 2009). Potato is a semi perishable in nature, it contains about 80% water and 20% dry matter. A major portion of dry matter is starch and sugar that constitutes 16% on fresh wet basis, crude protein content is 2% (Singh et al. 2007). Potato chips are a thin slice of potato, deep fried or baked until crisp or crunchy. It serves as an appetizer, side dish or snack. Potato chips have been popular salty snacks for 150 years, basic chips are cooked and salted but manufactures can add wide variety of flavoring herbs, spices, cheese, color and artificial additives. Traditional potato chips have a high oil content that ranges from 35 to 45 g 100 g^{-1} (wet basis), which gives the product a unique texture and flavor to make them appeal to the consumer (Mellema, 2003). High oil content is therefore a major factor affecting consumer acceptance of oil-fried products today and the low fat food products are becoming more popular (Bunger et al., 2003). In particular, during the past 10 years, the American Heart Association and other health organizations have encouraged reduction of fats in foods to less than 30% of calories for most people (USDA, 1990; USDA & USDHHS, 1990). Saturated fat and trans-fat are the undesirable fats (Allan, 2004). Reducing oil content in potato chips is motivated by other reasons also; oil is a costly raw material and is an important determinant of the cost of a product. A high oil content often makes the chips greasy or oily. On the other hand, it is possible to make chips so low in fat content that they lack flavor and seem harsh in texture (Prosise, 1990). In recent years, increasing public concern over deep-oil-fried snack foods has motivated the food industry and research communities to explore new means for the production of lower oil content or non-fat products. Much of the research has been concentrated on approaches to reduce oil absorption in fried products (Song et al., 2007; Pedreschi and Moyano, 2005; Krokida et al., 2001). The initial solids content in the product to be fried is a critical factor that influences oil uptake during frying (Pinthus, 19993). Drying of potato before frying using microwave, hot-air treatment and baking can result in a significant reduction in oil content of different products (Fan, 2005). Microwave drying has been studied as an alternative method for improving the quality of dehydrated products (Zhang et al., 2005; Wang et al., 2004)

There are a number of advantages of microwave baking in food processing technology like significant reduction in the thermal processing time while making food safe for consumption is the major advantage of microwave sterilization processing, reduction in processing time results in more fresh-like taste and texture, and improves visual appeal of the food. The reduction of processing time may also potentially increase retention of nutrients in the thermally processed foods. Instantaneous turn-on and off of the process allows for a more precise process control, better energy usage, and cleaner working environment in food processing facilities (Chavanet al. 2010).

2. MATERIALS AND METHODS

2.1 Experimental Procedure

Selected mature potatoes were washed and peeled by potato peeler. The peeled potatoes were trimmed to remove any discolored region or green area. It was sliced into thickness 2±10% mm and blanched in hot water + 2% NaCl Solution at (72 ± 5^0C) for 6 min. The blanched potatoes were partially dehydrated in tray drier at 60^0C for 1, 1.5,2, 2.5 and 3 hours. The moisture content of partially dehydrated samples were observed and then tomato puree was added to the potato slices then again potato slices were dried at 60ºc for 30 min. after that these are baked in microwave at different powers such as 20W,40W, 60W, 80W and 100W. After baking the samples were cooled, packed and further qualitative analysis was conducted.

2.2 Experimental design

Response surface methodology (RSM) was adopted in the design of experimental combinations (Altan et al., 2008; Yagci and Gogus, 2008; Ding et al., 2005; Montgomery, 2001). The main advantage of RSM is the reduced number of experimental runs needed to provide sufficient information for statistically acceptable results. A three-variable (five levels of each variable) central composite rotatable experimental design was employed (Montgomery, 2001; Yagci and Gogus, 2008). The independent variables included dehydration time of (60-180min), microwave power of (20-100W), and baking time of (10-50sec). The five levels of the process variables were coded as -2.0, -1, 0, +1, +2.0 (Montgomery, 2001) and design in coded (x) form and at the actual levels A, B, C, and D are given in Table 1.

2.3 Analytical methods

2.3.1 Moisture content

The potato chips were ground with a mortar after microwave baking. Moisture content was determined using approximately 3.0g of the ground potato chips in a forced air oven at 105ºc until the weight constant (AAOC, 1984).The test was performed in duplicate and in average value taken.

2.3.2 Oil content

The microwave baked potato chips were ground and oven dried. Fat content of potato chips was determined by Soxhlet apparatus using petroleum ether (AAOC, 1984). The test was performed in duplicate.

2.3.3 Protein content

The protein content of microwave baked potato chips was determined by micro kjeldhal apparatus (AAOC, 1984).The test was performed in duplicate.

2.3.4 Ash content

The ash content of potato chips was determined by muffle furnace (AAOC, 1984).. The test was performed in duplicate

2.3.5 Sensory analysis

Sensory analysis was conducted for all the samples. The panelists were mark on a Hedonic Rating Test (1 – Dislike extremely, 5 – Neither like nor dislike and 9 – Like extremely) in accordance with their opinion for flavor, texture and overall acceptability.

2.3.6 Texture

Textural properties of the microwave baked potato chips were determined by using a TA–XT2 texture analyzer

(Stable Micro Systems Ltd., Godalming, UK) equipped with a 500 kg load cell. An rounded chips was compressed with a probe SMS P/75 – 75 mm diameter at a crosshead speed 5 mm/s to 3 mm . The compression generated a curve with the force over distance. The highest first peak value was recorded as this value indicated the first rupture of snack at one point and this value of force was taken as a measurement for hardness (Stojceska et al., 2008).second peak was taken as fractureness.

Statistical Analysis

Data were analyzed using the statistical analysis system software package (Design expert, trial version 6.0.10). Analysis of variance was performed by the ANOVA procedure. Mean values were considered significantly different when $P<0.05$. The adequacy of the regression model was checked by R^2, Adjusted R^2, Adequate Precision and Ficher's F-test (Montgomery, 2001). The regression coefficients were then used to make statistical calculation to generate three dimensional plots for the regression model.

3. RESULTS AND DISCUSSION

Variation of responses (protein, fat, moisture, ash, texture and flavor) of microwave baked chips with independent variables (dehydration time, microwave power, and baking time) are shown in Table 2. A complete second order model (Equation 5) was tested for its adequacy to decide the variation of responses with independent variables. To aid visualization of variation in responses with respect to processing variables, series of three dimensional response surfaces (Figures 1 to 6) were drawn using design expert software (Statease 6.0).

3.1 Protein Content

Figure 1, and 2, represents the effect of dehydration time, microwave power, and baking time on the protein content of potato chips during microwave baking. The dehydration time and microwave power significantly ($P<0.05$) affects the protein content of potato chips during microwave baking. It may be observed from Figure 1 shows the effect of dehydration time and microwave power on protein content of potato chips. Where dehydration time increases the protein content will be increase but microwave power was increases the protein content will be decreases so microwave power has significant effect on protein content, It may be observed from Figure 2 shows the effect of dehydration time and baking time on protein content of potato chips, the protein content initially decreased with dehydration time and baking time there after increases which may be due to cooking and baking does not cause significant changes in total nitrogen & protein content. similar observations were reported by (McCay, 1987).In this analysis independent variable microwave power was significant (p value is 0.0010).

3.2 Oil Content

Oil content of microwave baked tomato flavored potato chips were observed to be 0.28% to 0.44% in different dehydration time, microwave power and baking time has shown in figure 3,4. The dehydration time and microwave power and baking time significantly ($P<0.05$) affects the oil content of potato chips during microwave baking. It was perceived from Figure 3 the dehydration time and microwave power increases the oil content will be decreases, where has The contour plot in Figure 4 demonstrate the initial increases the oil content with the increase in dehydration time and baking time whereas further decreases , which may be attributed microwave energy cooks foodstuff while the cooking oil browns the exterior of the foodstuff to provide the desired surface finishing (Kita and Figiel 2008). Similar observations were reported by (Miranda& Aguilera 2006) .The dehydration time and baking time are insignificant terms (p value>0.05) and microwave power is significant independent variable. Analysis of variance could attribute 74% of total variation of oil with dehydration time, microwave power, baking time.

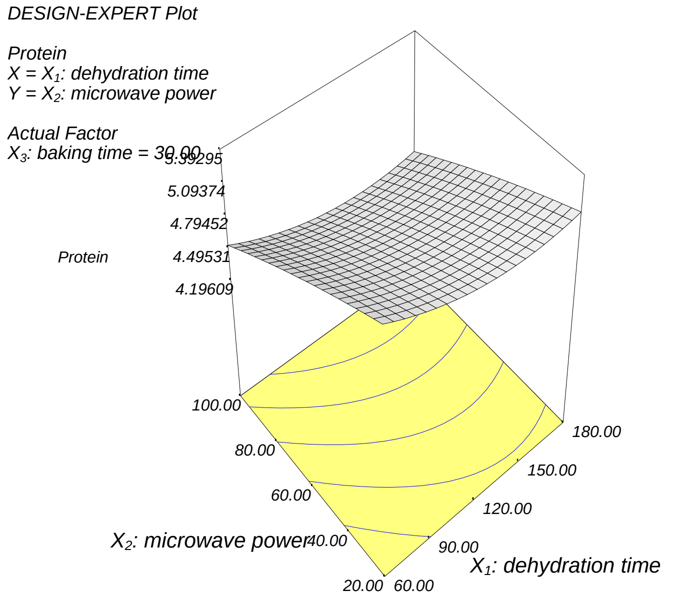

Figure1: Response surface plot of protein content (%) of potato chips as a function of dehydration time and microwave power at constant baking time (30 sec)

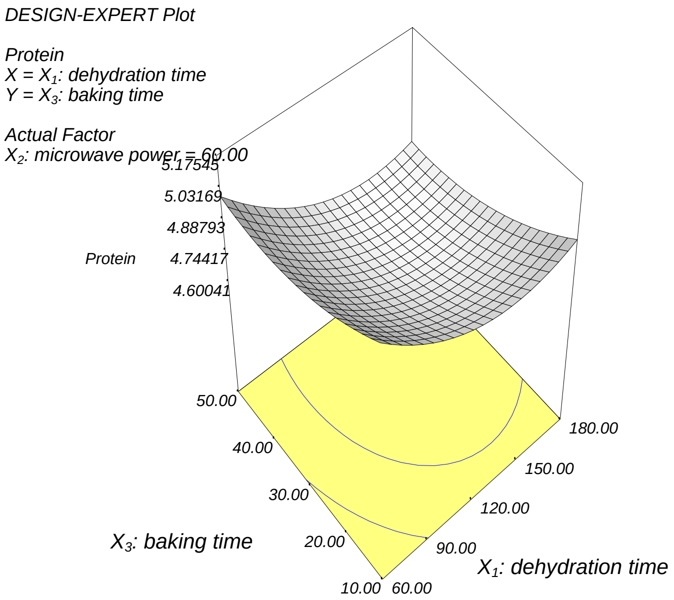

Figure2: Response surface plot of protein content (%) of potato chips as a function of dehydration time and baking time at constant microwave power (60 Watts)

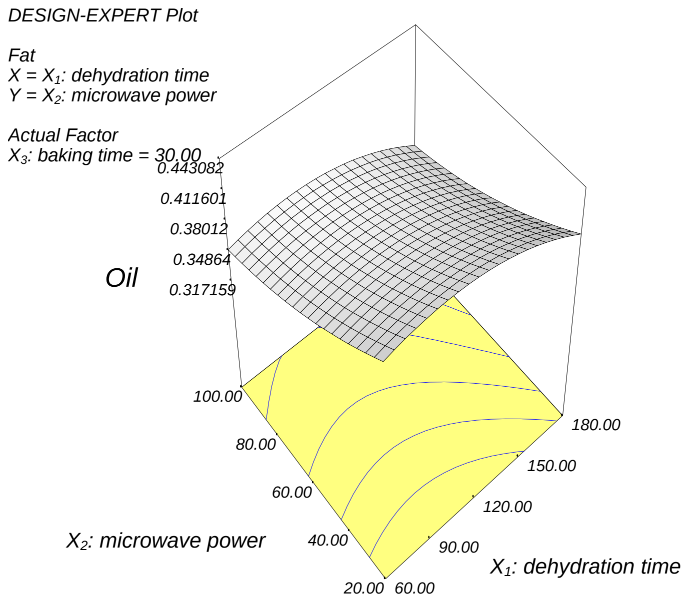

Figure 3: Response surface plot of oil content (%) of potato chips as a function of dehydration time and microwave power at constant baking time (30 sec)

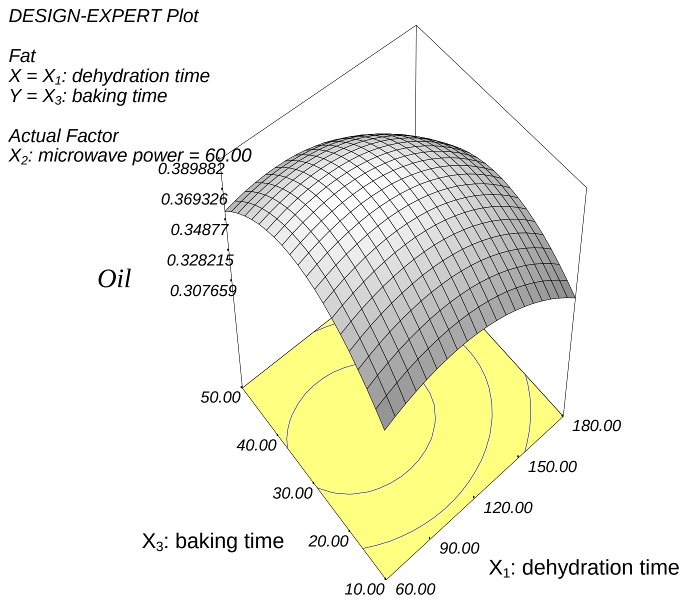

Figure 4: Response surface plot of oil content (%) of potato chips as a function of dehydration time and baking time at constant microwave power (60 Watts)

3.3 Moisture Content

Moisture content of microwave baked tomato flavored potato chips were observed to be 5.1% to 2.6% in different dehydration time, microwave power and baking time as shown in figure 5,6.The moisture content decreases with increase in dehydration time, microwave power, baking time. The dehydration time and microwave power and baking time significantly (P<0.05) affects the moisture content of potato chips during microwave baking. It was perceived from Figure 5 shows that the dehydration time and microwave power increases the moisture content will be decreases, where has in figure 6 shows the dehydration time increases the moisture content will be gradually decreased and baking time increases, which may be attributed to microwave heating on nutritive value of foods. which indicated that microwave cooking resulted in higher moisture losses. **(**Gwendolyn et al.,1982). The final moisture content of chips is critical as it not only influences the chips stability from microbial storage but also contributes to the final crisp texture (Miranda & Aguilera, 2006). The moisture content will effect the texture which should not only be crispy immediately after frying but also during month of storage (Lisinka 1989). Analysis of variance could attribute 90.49 % of total variation of moisture with dehydration time, microwave power, baking time. The optimum value of moisture at this zone of optimization was found to be about 3.86%.

3.4 Ash Content

Ash content of microwave baked tomato flavored potato chips were observed to be 2.5% to 4.2% in different dehydration time, microwave power and baking time as shown in figure 7, 8. The dehydration time and microwave power and baking time significantly (P<0.05) affects the ash content of potato chips during microwave baking. In Figure 7 shows that the dehydration time and microwave power increases the ash content will be increases, where has in figure 8 shows that the dehydration time increases the ash content will be gradually increased but baking time increases the ash content will decreases initially and later on increases which may be attributed to the dehydration time, microwave power are significant independent variables and the quadratic effect of baking time are positive and significant (individual p values is 0.0148). Analysis of variance could attribute 90.99 % of total variation of ash with dehydration time, microwave power, baking time. The optimum value of ash at this zone of optimization was found to be about 3.89%.

3.5 Flavour

Flavor of microwave baked tomato flavored potato chips were observed to be 6.5 to 8.3 in different dehydration time, microwave power and baking time as shown in figure 9 ,10. The dehydration time and microwave power and baking time significantly (P<0.05) affects the flavor of potato chips during microwave baking. The flavor of potato chips is more complex than that of boiled, baked or mashed potatoes, since the cooking temperature are higher and the absorbed oil contributes overall flavor profile of the product (Scanlon,2003). It may be observed from Figure 9 shows that the dehydration time increases the flavor will be increased, where has microwave power increases the flavor will be increased first and later on decreased slightly compared to dehydration time. Where has in figure 10 shows the dehydration time increases the flavor will be gradually increased and later on slightly decreased but the baking time increases the flavor will be increased constantly. The quadratic effect of dehydration time are positive and significant (individual p values is 0.0218).Analysis of variance could attribute 83.09 % of total variation of flavor with dehydration time, microwave power, baking time. The optimum value of fat at this zone of optimization was found to be about 7.98.

3.6 Texture

Texture of microwave baked tomato flavored potato chips were observed to be 6.6 to 8.4 in different dehydration time, microwave power and baking time as shown in figure 11,12. The dehydration time and microwave power and baking time significantly (P<0.05) affects the texture of potato chips during microwave baking. One of the desirable textural attributes of potato chips is often described as crispness (Kita,2002; Segnini et al.,1999).I may be observed from Figure 11 shows that the dehydration time increases the texture will be increased gradually fist and later slightly decreased , where has microwave power increases the texture will be increased constantly. Where has in figure 12 shows the the baking time increases the texture will increase constantly, Where has dehydration time increases the texture will be increased gradually fist and later slightly decreased. The quadratic effect of dehydration time are positive and significant (individual p values is 0.0209). Analysis of variance could attribute 72.93% of total variation of fat with dehydration time, microwave power, baking time.

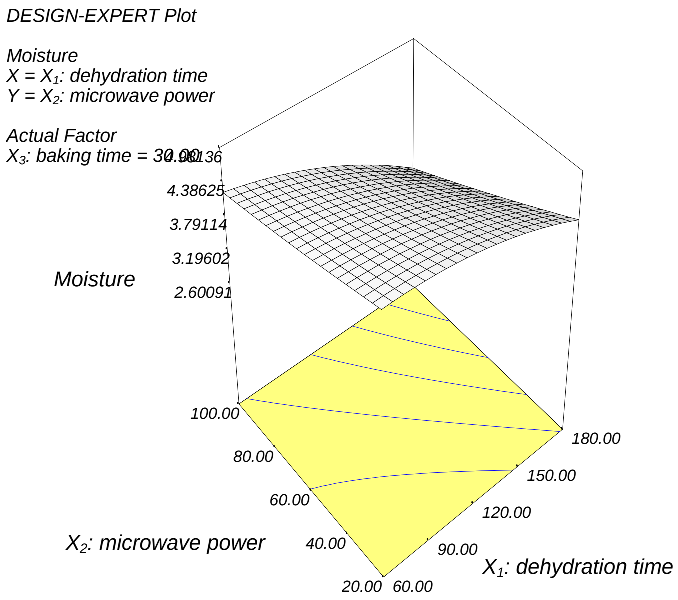

Figure5: Response surface plot of moisture content (%) of potato chips as a function of dehydration time and microwave power at constant baking time (30 sec)

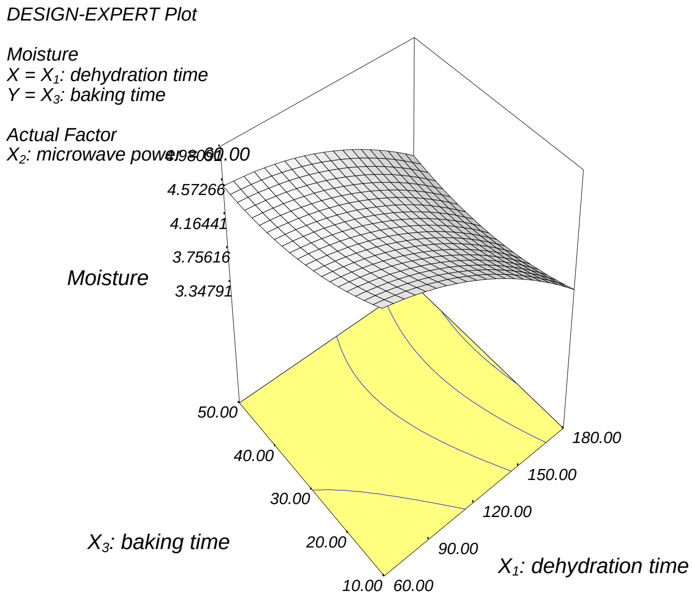

Figure 6: Response surface plot of moisture content (%) of potato chips as a function of dehydration time and baking time at constant microwave power (60 Watts)

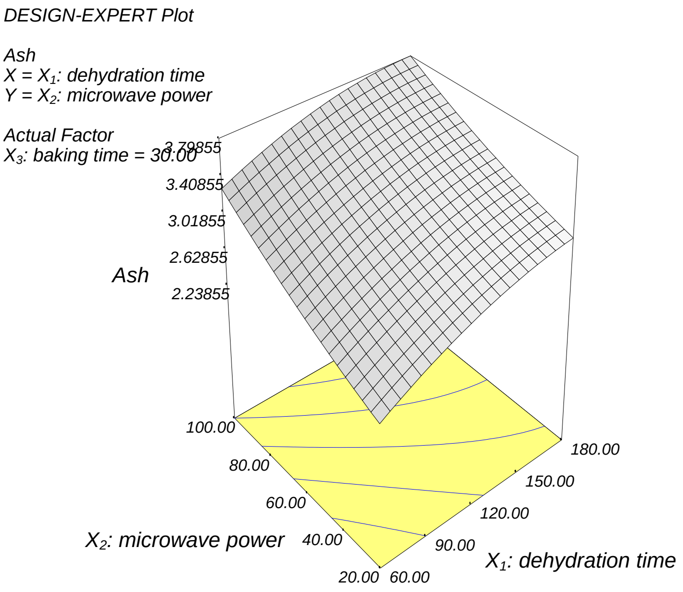

Figure7 : Response surface plot of ash content (%) of potato chips as a function of dehydration time and microwave power at constant baking time (30 sec)

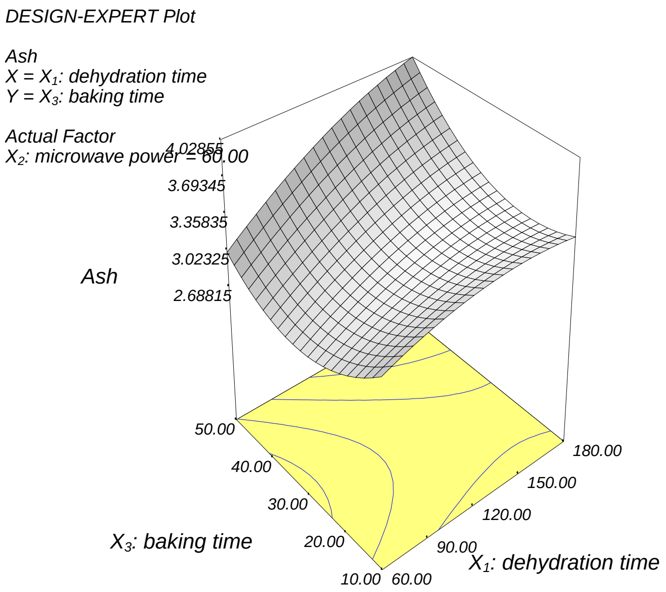

Figure 8: Response surface plot of ash content (%) of potato chips as a function of dehydration time and baking time at constant microwave power (60 Watts)

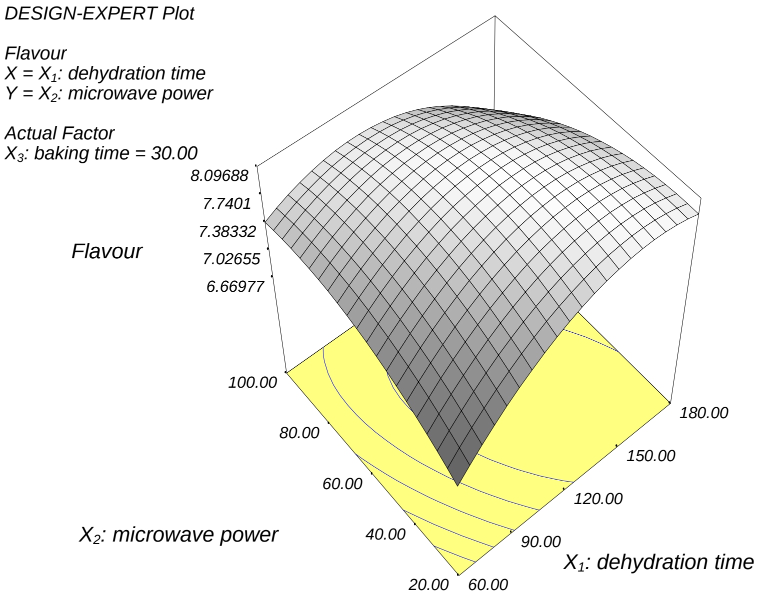

Figure9 : Response surface plot of flavor of potato chips as a function of dehydration time and microwave power at constant baking time (30 sec)

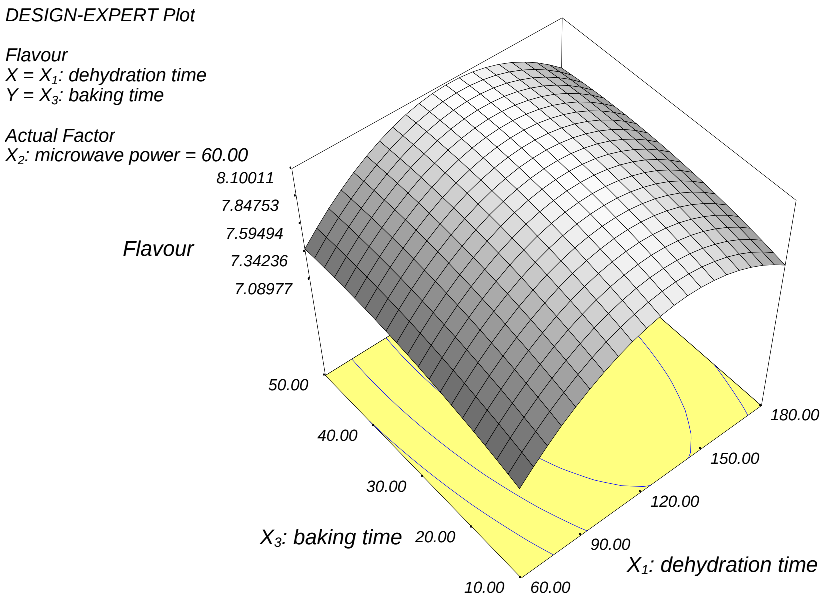

Figure 10 : Response surface plot of flavour of potato chips as a function of dehydration time and baking time at constant microwave power (60 Watts)

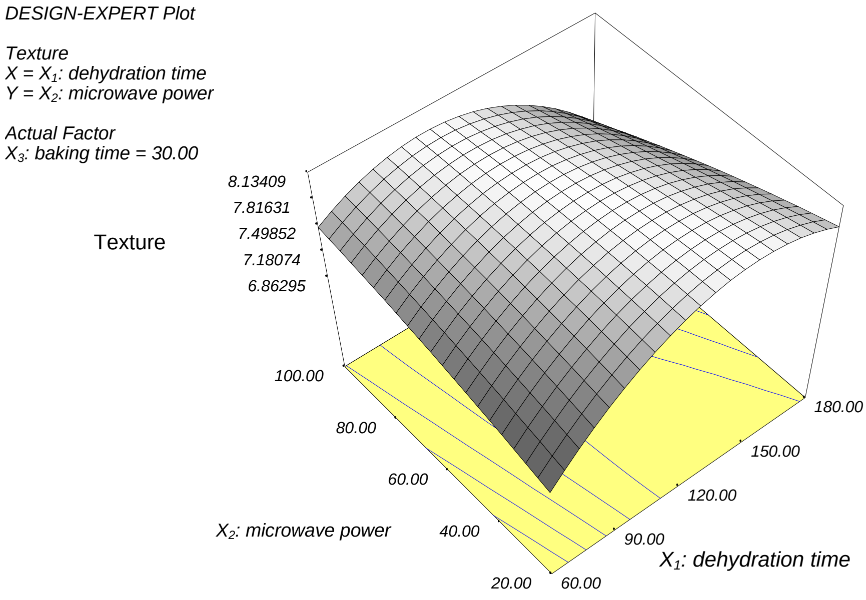

Fig 11: Response surface plot of texture of potato chips as a function of dehydration time and microwave power at constant baking time (30 sec)

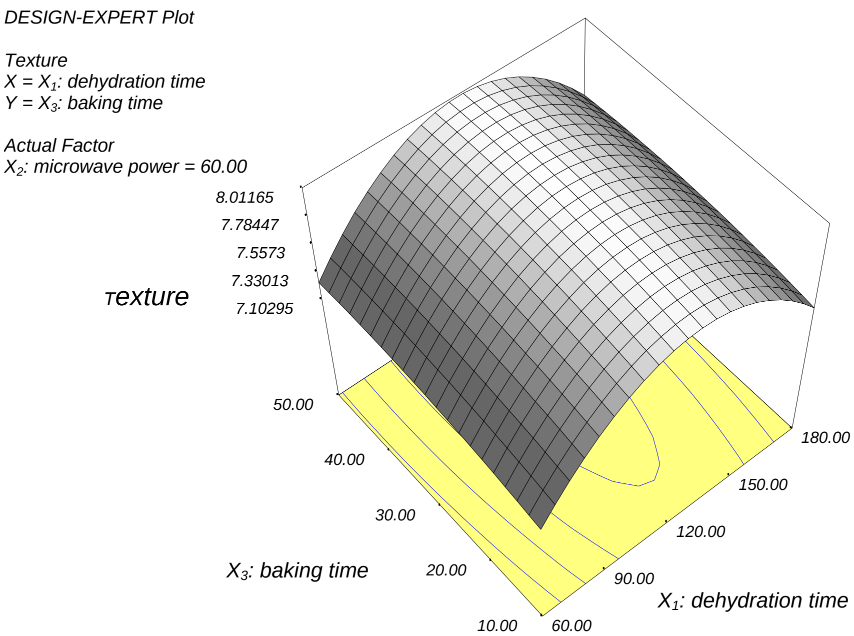

Fig 12 : Response surface plot of texture of potato chips as a function of dehydration time and baking time at constant microwave power (60 Watts)

4. OPTIMUM CONDITION

Optimum conditions for microwave baked tomato flavored potato chips were determined to obtain maximum protein and ash content and minimum moisture and fat content. Second order polynomial models obtained in this study were utilized for each response to determine the specified optimum conditions. The sequential quadratic programming in Design- Expert D x 6.0.10 is used to solve the second degree polynomial regression equations. The optimum values obtained by substituting the respective coded values of variables are 151.20 min, 61.99 watts, 50 sec. At this point, protein, fat, moisture, ash content, flavor and texture was calculated as 4.583%, 0.333%, 3.864%, and 3.897%, 8.01, 7.98, 7.84 restively.

5. CONCLUSION

It can be concluded from this study that dehydration time and microwave power were the most pronounced factors affecting physico-chemical parameters during microwave baking of tomato flavored potato chips. Results obtained evident that microwave baking was able to improve the quality of tomato flavored potato chips in term of the texture, flavor, taste, aroma, appearance as well as overall acceptability. The regression equations obtained in this study were successfully used to predict optimum conditions for the low fat content of microwave baked potato chips. Using microwaves in chips preparation removes oil content of potato chips by frying and It is an alternative to conventional deep fat frying of potato chips.

6. ACKNOWLEDGEMENTS

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Table1: The central composite rotatable experimental design (in coded and un coded levels of four variables and five levels) employed for development of of Microwave Baked Potato Chips Using Tomato Flavour

	Independent variables			dependent variables values					
Run	X_1	X_2	X_3	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Flavour	Texture
1.	0	0	0	4.9	0.4	4	3	8	7.9
2.	-2	-2	-2	5.3	0.38	5.2	2.8	6.5	6.9
3.	-2	2	-2	4.8	0.35	4.8	3.6	7.4	7.6
4.	2	2	2	4.2	0.28	2.6	4.2	6.7	6.6
5.	0	2	0	4.3	0.32	3.9	3.8	7.4	7.8
6.	2	-2	2	5	0.36	4.3	3.9	7.7	7.6
7.	0	0	0	4.5	0.42	3.7	3.1	8.2	8
8.	0	0	0	4.3	0.38	4.2	3.3	8.3	8.2
9.	2	2	-2	4.45	0.3	2.8	4	6.8	6.7
10.	0	0	0	4.7	0.43	4.1	2.9	7.8	7.7
11.	0	0	0	4.6	0.41	3.8	3.2	8	7.9
12.	-2	2	2	4.4	0.31	3.9	3.7	7.6	7.6
13.	0	0	0	4.25	0.39	4.5	3.08	7.9	7.8
14.	2	-2	-2	5.15	0.37	4.3	2.7	7.5	7.6
15.	-2	0	0	5.2	0.34	4.7	2.6	6.9	6.7
16.	-2	-2	2	5.5	0.44	5.1	2.5	6.7	6.9
17.	2	0	0	4.9	0.33	3.6	3.5	8.2	8.2
18.	0	0	-2	5.25	0.31	4.6	3.4	7.7	7.7
19.	0	-2	0	5.4	0.42	4.9	2.7	8.2	8.3
20.	0	0	2	4.7	0.34	4.5	3.7	8.3	8.4

X_1=Dehydration time X_2= Microwave power level X_3= Baking time

Table2: Regression coefficients of second order polynomial and their significance for protein, fat and moisture content

		Protein content(%)			fat content (%)			moisture content(%)		
s/no	coefficients	Coeff.value	F	P	Coeff. value	F	P	Coeff value	F	P
1	x_1	-0.15	2.72	0.130	-0.018	2.93	0.1175	-0.61*	44.56	<0.0001
2	x_2	-0.42*	21.34	0.001	-0.041*	15.22	0.003	-0.58*	40.28	<0.0001
3	x_3	-0.12	1.6	0.2346	2.000E-003	0.036	0.8529	-0.13	2.02	0.1853
4	x_1^2	0.17	0.92	0.3611	-0.023	1.34	0.2742	-0.22	1.57	0.239
5	x_2^2	-0.034	0.039	0.8480	0.012	0.35	0.5684	0.032	0.033^{ns}	0.8588
6	x_3^2	0.091	0.27	0.6114	-0.033	2.74	0.1288	0.18	1.09	0.3213
7	$x_1.x_2$	0.013^{ns}	0.015	0.9046	$1.25E\text{-}003^{ns}$	0.011	0.9174	-0.20	3.83	0.0788
8	$x_1.x_3$	-0.025	0.06	0.8107	-6.250E-003	0.28	0.6064	0.10	0.96	0.3508
9	$x_2.x_3$	-0.087	0.74	0.4095	-0.014	1.37	0.269	-0.12	1.5	0.2492
10	R2	0.7447			0.7400			0.9049		
11	Adjusted R2	0.5150			0.5061			0.8192		
12	Adequate precision	6.739			7.367			12.920		
13	Lack of fit	0.52			9.293E-003			0.42		
14	F-value	3.24			5.31			10.57		

*Significant at1%   ns – not significant, E=10^{-3},

Table3:Regression coefficients of second order polynomial and their significance for ash content, texture,and flavour

		Ash content (%)			texture			flavour		
s/no	coefficients	Coeff.value	F	P	Coeff. value	F	P	Coeff value	F	P
1	x_1	0.31	22.16	0.0008	0.1	0.63	0.4468	0.18	2.91	0.1186
2	x_2	0.47*	50.93	0.0001	-0.1	0.63	0.4468	-0.07	0.44	0.5218
3	x_3	0.15	5.19	0.046	0.06	0.23	0.6449	0.11	1.09	0.3215
4	x_1^2	-0.13	1.09	0.3218	-0.66*	7.49	0.0209	-0.55	7.36	0.0218
5	x_2^2	0.069^{ns}	0.30	0.5943	-0.059	0.06	0.8111	-0.3	2.16	0.1725
6	x_3^2	0.37	8.64	0.0148	-0.059	0.06	0.8111	-0.095^{ns}	0.23	0.6452
7	$x_1.x_2$	-0.050	0.46	0.5125	-0.41	8.54	0.0153	-0.44*	13.77	0.004
8	$x_1.x_3$	0.20	7.38	0.0217	-0.012^{ns}	7.84E-03	0.9312	-0.037	0.1	0.757
9	$x_2.x_3$	-0.075	1.04	0.3324	-0.012^{ns}	7.84E-03	0.9312	-0.037	0.1	0.757
10	R2	0.9099			0.7293			0.9049		
11	Adjusted R2	0.8288			0.4856			0.8309		
12	Adequate precision	12.630			4.660			7.139		
13	Lack of fit	0.33			1.45			0.94		
14	F-value	11.22			2.99			5.46		

*Significant at1%, ns = not significant, $E=10^{-3}$,