International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 2, 2017, pp.-3658-3662.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

COLOUR AND TEXTURAL CHANGES DURING OSMO-AIR DEHYDRATION OF NENDRAN BANANA BY USING RSM

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Received: December 28, 2016; Revised: January 08, 2017; Accepted: January 09, 2017; Published: January 12, 2017

Abstract- Osmotic dehydration of banana pieces using sugar solution with additives was reported. Three types of different concentrated solutions with different thickness, shapes and time were studied. Color and Textural properties were fitted to a RSM model and report resulted that color and textural qualities increases as concentration, time, thickness increases. The presence of preservatives (citric acid, ascorbic acid, KMS) in the osmotic solution helped to increase the quality for longer period. The effect of osmotic dehydration on the colour parameters (chroma) and rheological properties (stress at rupture and relaxation time) were investigated in the experiment. Chroma values were increased, denoting colour intensification along the process. Effective in reinforcing tissue structure, presenting stress at fracture values for dehydrated banana with preservatives around three-fold higher than for other treatments. The dehydrated product water activity reduced to 17 to 18% moisture so that microbial growth was prevented up to 6 months.

Keywords- Banana, Osmotic Dehydration, Colour, Texture

Citation: Keerthishree M., *et al*., (2017) Colour and Textural Changes during Osmo-Air Dehydration of Nendran Banana by Using RSM. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 2, pp.-3658-3662.

Academic Editor / Reviewer: Bommesh J.C., Kattula Nagaraju

Introduction

Osmotic dehydration is an operation used for partial removal of water from plant tissues by immersion in an osmotic solution. This is a useful technique to decrease energy cost of processing and to extend the shelf life. It also helps to improve sensorial, nutritional and organoleptic properties of food. Dehydration techniques, including osmotic dehydration induce significant changes in the dehydrated material and have an impact on dietary value [24]. Osmotic dehydration techniques not only enable the storage of fruits for a longer period, but also preserve flavor, nutritional characteristics and prevent microbial spoilage. Through dehydration, problems of marketing, handling and transport becomes much simpler and banana could be made available to consumer throughout the year.

Fruits and vegetables undergo volumetric changes upon water loss which is expressed as textural quality. Such modifications occurring during drying process affect the moisture transport properties as well as structure and color changes of the product [20], [5] in case of aonla; [3] in case of coconut. Hence the present work focused on the textural qualities and the color changes during osmotic dehydrated banana slices. Some of the supported works has been reviewed below.

The textural property of strawberries had a linear relation with moisture ratio and equivalent diameter had a reciprocal logarithmic function with moisture ratio [20]. The jackfruit samples dried at 60 ºC were found better as compared to sample obtained at 50 and 70 ºC in terms of 'a' and 'b' value and sugar impregnation maintained luminosity, resulted in a final product very close to the fresh fruit [1]. Longer osmotic concentration and time resulted in higher loss of phytonutrients, mainly due to the leaching into sucrose solution and negative influence of oxygen [12]. The conducted an experiment to study the suitability of seven banana varieties (Grand Naine, Rajapuri, Yanagambi KM-5, Monthan, Yalakkibale, Kothia and Bluggoe) for making osmo-dehydrated banana crisps. The variety Yalakkibale recorded higher recovery (57.49%) of crisps and lower dehydration ratio (1.74) and it was due to higher TSS, low moisture and high dry matter content than the other varieties [14]. The textural qualities like cutting force and cutting energy decreased in case of osmotically dehydrated papaya slices and it may be due to water loss [6].

Enzymatic browning during air dehydration of apricots was due to phenolase activity, which had been decreased rapidly with increase in soluble solids content [18] [9] and colour parameters showed slight change after the osmotic step; a* and b* maintain their original values (no browning), whereas L* values show a little decrease (darkening) and lower darkening for osmo dehydrated samples. These results are in accordance with those obtained on apple and, banana and [23] on pineapple. The osmodehydration helped in reducing the browning of banana fruits during air drying [7]. The decrease in color occurred throughout storage in pineapple juice due to browning reaction [16]. A decrease in color intensity was recorded in pineapple slices and mango chips due to osmodehydration [8]. In fruits like strawberry, fructose promotes colour degradation during processing while sucrose stabilizes anthocyanin level [27].

Materials and Methods

Sugar syrup (sucrose) of three different concentrations *viz*. 50, 60, 70 ºB was prepared. Potassium metabisulphite (0.1%), citric acid (0.1%), and ascorbic acid

(0.2%), were added to the osmotic solution [26].

Prepared nendran banana slices of one kg each were osmosed in 50, 60 and 70 °B sugar syrup for different immersion time of 40, 60 and 80 minutes. At the end of osmotic treatment for a particular shape, thickness, concentration and osmotic duration, the fruit slices were taken out of the osmotic solution and were rinsed quickly with distilled water in order to remove the sugar adhering to the surface and were blotted to remove moisture. Known weight of osmosed slices of banana were kept in a cabinet tray drier (Gallen Kamp hot box). Banana slices were air dried at 55-60 °C temperature till the fruit slices reached 17±1% moisture content [15].

Browning index (BI)

Colour of the dehydrated product was recorded using Konica Minolta colourimeter [Plate-1.] by measuring 'L', 'a' and 'b' values where 'L' indicates lightness or darkness, 'a' greenness or redness and 'b' blueness or yellowness. From these primary colour values, the browning index was calculated as below given by the commission Internationale d' Eclairag given by [17].

$$\mathrm{BI} = \frac{100\ (\times -0.31)}{0.17}$$

$$\text{Where X} = \frac{(a + 1.75\mathrm{L})}{(5.645\mathrm{L} + \mathrm{a} - 3.012\mathrm{b})}$$

Textural properties

Textural properties of the dried slices were measured using a texture analyzer TA–HD® (Stable Micro systems, Surrey, England). Following conditions/settings were adopted for the experiments, mode-force/cutting: option-return to start, prespeed = 1.5 mm/s; speed = 1 mm/s; post speed = 10 mm/s; distance = 20 mm; trigger force = 0.02 kg; acquisition rate (pps) = 20. The samples were placed on the platform of the texture analyzer in their natural resting position to get a uniform contact area between the platform and cutting device. The slices were placed with their major axis perpendicular to the knife edge [Plate-2]. Cutting force (N) was measured by cutting the samples by fixing a HDP/BSK blade set with knife provided along with the instrument and cutting energy (Ns) of the samples was measured as area from the graph plotted with force and time as Y and X axis [22].

Plate-1 Konica Manolita colourimeter

Plate-2 Food Texture analyser

Result and Discussion

Browning index

Browning index shows the colour changes towards the brownness of the product. Longitudinal slices recorded minimum browning index of 134.67 (thickness 6.95 mm, concentration 57.7 °B and 44.68 minutes immersion time) as shown in [Table-1 and 2] and, 134.58 for round slices (thickness 7.69 mm, concentration 53.0 °B and immersion time 49.08 minutes) in as shown in [Table-3 and 4] and, 127.74 % for ring slices (thickness 6.76 mm, concentration 56.02 °B and immersion time 46.98 minutes) [Table-5 and 6]. Browning index showed increasing trend with increase in osmostic solution concentration based on their shapes [Fig-1,2,3]. It may be due to an increase of soluble solids content of the fruit. Higher sugar concentration may have resulted in the browning. [2] in papaya also reported that colour development of osmotic dehydrated fruits increased with concentration. Increased browning index may be due to Millard reactions by [17].

The predictive model for banana slices is

BI= $133.787+1.342X_1-4.198X_2+1.577X_3-0.277X_{11}+1.033X_{22}+0.301X_{33}+0.757X_1X_2-0.351X_1X_3+0.036X_2X_3$ for longitudinal slices

BI= $128.04+0.585X_1+0.56X_2+2.276X_3+0.513X_{11}+0.853X_{22}-0.169X_{33}-0.391X_1X_2-0.068X_1X_3+0.127X_2X_3$ for round slices

BI = $112.148+5.327X_1-0.034X_2+7.463X_3-0.498X_{11}+0.736X_{22}-0.445X_{33}+0.702X_1X_2-0.979X_1X_3-0.706X_2X_3$ for ring slices

Table-1 *Regression equation coefficients for osmo-air dehydrated longitudinal nendran banana slices*

Model	Browning index	Texture	
		Cutting force	Cutting energy
Intercept	133.787**	-1.122NS	31.367**
	Linear		
X_1 (Thickness)	1.342NS	18.477**	-0.931NS
X_2 (Concentration)	-4.198**	2.664**	-3.172*
X_3 (Time)	1.577NS	2.177**	1.357NS
	Quadratic		
X_{11} (Thickness*Thickness)	-0.277NS	-2.151**	1.008**
X_{22} (Concentration*Concentration)	1.033**	0.253NS	0.972**
X_{33} (Time*Time)	0.301NS	-0.188NS	-0.171NS
	Interaction effect		
X_1X_2 (Thickness*concentration)	0.757**	-0.797**	0.207NS
X_1X_3 (Thickness*Time)	-0.351NS	-0.151NS	0.041NS
X_2X_3 (Concentration*Time)	0.036NS	-0.151NS	-0.087NS
R^2	95.30%	99.83%	97.08%
CV	0.49	1.13	1.97

Table-2 *Optimization of osmo-air dehydrated longitudinal nendran banana slices*

Browning index		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	134.67	6.95	57.7	44.68
Maximum	140.70	11.48	67.77	71.08
Texture				
Cutting force (N)		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	22.30	5.11	58.03	58.4
Maximum	38.67	14.71	63.03	62.82
Cutting energy (Ns)		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	30.95	5.45	57.91	52.78
Maximum	38.54	14.76	62.90	61.88

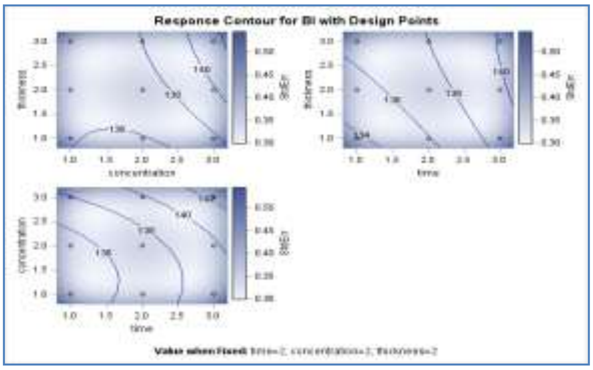

Fig-1 Change in BI of osmo-air dehydrated of longitudinally sliced nendran banana

Table-3 *Regression equation coefficients for osmo-air dehydrated round nendran banana slices*

Model	Browning index	Texture	
		Cutting force	Cutting energy
Intercept	128.04**	22.727**	49.885**
	Linear		
X_1 (Thickness)	0.585NS	3.451**	4.845**
X_2 (Concentration)	0.56NS	-1.654NS	-0.645NS
X_3 (Time)	2.276**	0.841NS	0.953NS
	Quadratic		
X_{11} (Thickness*Thickness)	0.513**	1.513**	-0.08NS
X_{22} (Concentration*Concentration)	0.853**	0.418NS	0.142NS
X_{33} (Time*Time)	-0.169NS	-0.138NS	0.064NS
	Interaction effect		
X_1X_2 (Thickness*concentration)	-0.391**	0.735**	0.392**
X_1X_3 (Thickness*Time)	-0.068NS	-0.015NS	-0.174NS
X_2X_3 (Concentration*Time)	0.127NS	0.221NS	0.05NS
R^2	99.10%	99.77%	99.60%
CV	0.30	1.36	0.54

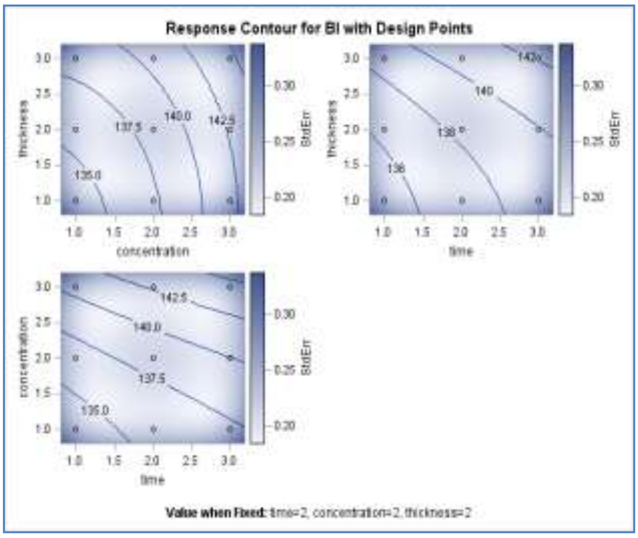

Fig-2 Change in BI of osmo-air dehydrated of round sliced nendran banana

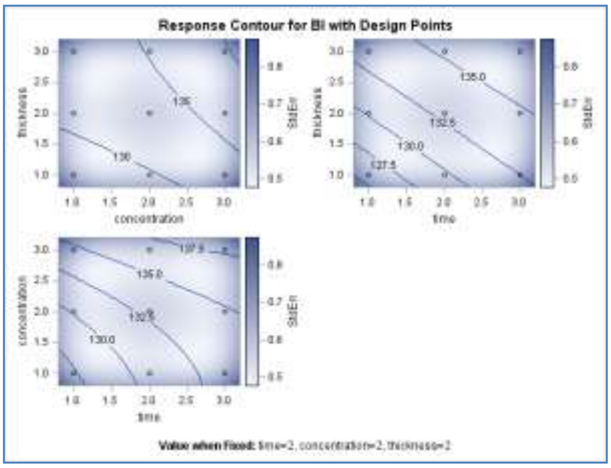

Fig-3 Change in BI of osmo-air dehydrated of ring sliced nendran banana

Texture: Texture is expressed in terms of cutting force and cutting energy and both showed increasing trend with increase in thickness and concentration. Osmotic dehydration increases the sugar to acid ratio and improves the texture and stability of pigments during dehydration [21]. [19] reported that for osmotically dehydrated strawberries texture was modified due to pectin dissolution and breakdown of cells after 30 minutes of pretreatment. [4] reported that multi regression analysis of cutting force revealed that there was no influence of concentration on cutting force. Increase in textural quality with concentration was reported due to solid diffusion into the fruit [11, 13].

Table-4 *Optimization of osmo-air dehydrated longitudinal nendran banana slices*

Browning index		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	134.58	7.72	68.75	63.25
Maximum	143.15	11.52	57.61	78.42
Cutting force (N)		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	29.40	5.814	63.14	68.96
Maximum	51.69	8.3	52.16	49.58
Cutting energy (Ns)		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	56.59	5.2102	62.64	62.22
Maximum	66.87	14.84	62.41	60.82

Table-5 *Regression equation coefficients for osmo-air dehydrated ring nendran banana slices*

Model	Browning index	Texture	
		Cutting force	Cutting energy
Intercept	112.148**	20.841**	7.161**
	Linear		
X_1 (Thickness)	5.327**	3.883**	10.057*
X_2 (Concentration)	-0.034NS	-2.117**	0.533NS
X_3 (Time)	7.463**	1.152NS	0.857NS
	Quadratic		
X_{11} (Thickness*Thickness)	-0.498NS	0.734**	0.556**
X_{22} (Concentration*Concentration)	0.736NS	0.689**	0.456NS
X_{33} (Time*Time)	-0.445NS	-0.067NS	0.168NS
	Interaction effect		
X_1X_2 (Thickness*concentration)	0.702*	0.517**	0.25NS
X_1X_3 (Thickness*Time)	-0.979**	0.056NS	0.556NS
X_2X_3 (Concentration*Time)	-0.706*	-0.165NS	-0.738NS
R^2	95.38%	99.73%	88.61%
CV	0.8203	1.2665	4.5051

Table-6 *Optimization of osmo-air dehydrated longitudinal nendran banana slices*

Browning index		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	127.74	8.45	62.61	78.28
Maximum	137.65	14.61	63.8	60.78
Cutting force (N)		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	42.94	14.95	58.75	58.9
Maximum	54.95	9.37	69.84	57.6
Cutting energy (Ns)		Thickness (mm)	Concentration (ºB)	Time (minutes)
Minimum	26.43	14.98	59.9	59.82
Maximum	42.68	9.19	68.48	49.92

Texture is reported as cutting force and cutting energy. Maximum cutting force of 38.67 N was obtained for slices with thickness 14.71 mm, concentration 63.08 °B and immersion time 62.82 minutes for longitudinal slices [Table-1 and 2], 51.69 N was obtained for slices with thickness of 14.89 mm, concentration 61.97 °B and immersion time 60.99 minutes for round slices [Table-3 and 4], 54.95 N was obtained for slices with thickness 14.55 mm, concentration 63.02 °B and immersion time 65.55 minutes for ring slices [Table-5 and 6]. Maximum cutting energy of 38.54 NS was obtained for slices with thickness 14.76 mm, concentration 62.90 °B and immersion time 61.88 minutes for longitudinal slices shown in [Table-1 and 2], 66.87 NS was obtained for slices with thickness of 14.77 mm, concentration 62.47 °B and immersion time 63.25minutes for round slices [Table-3 and 4], 42.68 NS was obtained for slices with thickness 14.866 mm, concentration 62.187 °B and immersion time 61.384 minutes for ring slices [Fig-4,5,6,7,8,9] based on their shapes of cutting force and energy as shown in [Table-5 and 6].

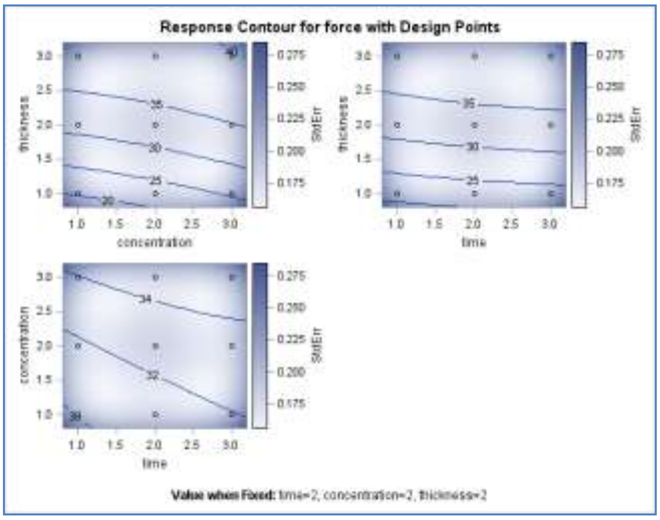

Fig-4 Change in cutting force of osmo-air dehydrated of longitudinally sliced nendran banana

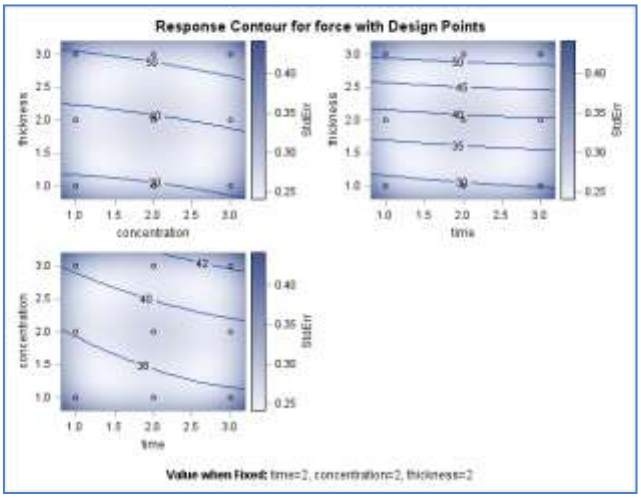

Fig-5 Change in cutting force of osmo-air dehydrated of round sliced nendran banana

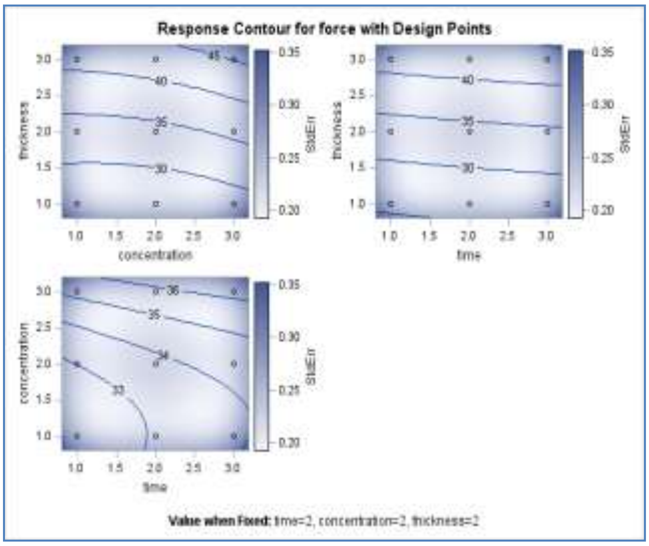

Fig-6 Change in cutting force of osmo-air dehydrated of ring sliced nendran banana

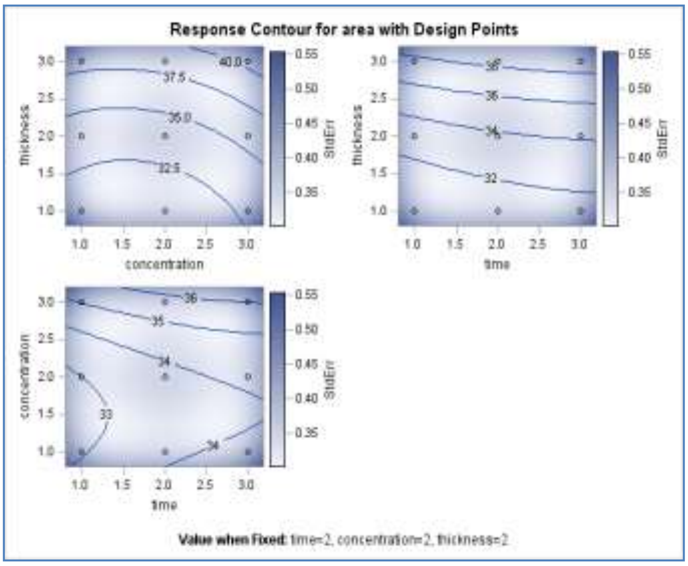

Fig-7 Change in cutting energy of osmo-air dehydrated of longitudinally sliced nendran banana

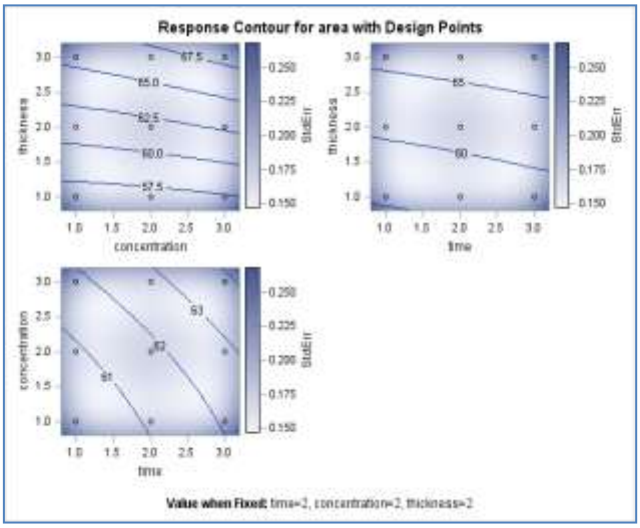

Fig-8 Change in cutting energy of osmo-air dehydrated of round sliced nendran banana

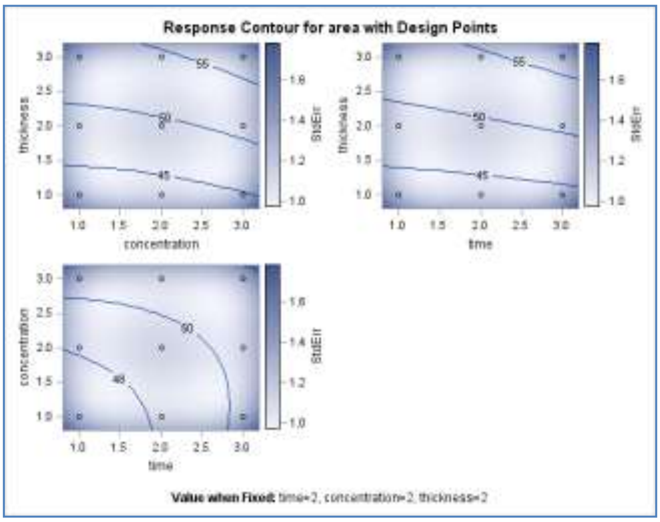

Fig-9 Change in cutting energy of osmo-air dehydrated of ring sliced nendran banana

For longitudinal slices* cutting force = $-1.122+18.477X_1+2.664X_2+2.177X_3-2.151X_{11}+0.253X_{22}-0.188X_{33}-0.797X_1X_2-0.151X_1X_3-0.151X_2X_3$

Cutting energy= $31.367-0.931X_1-3.172X_2+1.357X_3+1.008X_{11}+0.972X_{22}-0.171X_{33}+0.207X_1X_2+0.041X_1X_3-0.087X_2X_3$

For round slices**cutting force= $22.727+3.451X_1-1.654X_2+0.841X_3+1.513X_{11}+0.418X_{22}-0.138X_{33}+0.735X_1X_2-0.015X_1X_3+0.221X_2X_3$

Cutting energy = $49.885+4.845X_1-0.645X_2+0.953X_3-0.08X_{11}+0.142X_{22}+0.064X_{33}+0.392X_1X_2-0.174X_1X_3+0.05X_2X_3$

For ring slices*** No significant difference was obtained in the cutting force.

cutting energy = $7.161+10.057X_1+0.533X_2+0.857X_3+0.5562X_{11}+0.4566X_{22}+0.168X_{33}+0.25X_1X_2+0.556X_1X_3-0.738X_2X_3$

Conclusion

The experiment to study the osmotic dehydration of banana pieces using different concentrated solutions with different thickness, shapes and time were studied. Color and Textural properties were fitted to a RSM model and report resulted that, color and textural qualities of banana pieces increases as concentration, time, thickness increases. Chroma values also increased, denoting colour intensification along the process. Effective in reinforcing tissue structure, presenting stress at fracture values for dehydrated banana with preservatives around three-fold higher than for other treatments. Due to reduced water activity microbial growth inhibited effectively and stored upto six months with optimum quality.

Application of research: The present research on colour and textural characters of osmodehydrated nendran banana has direct implications on sensory qualities and consumer acceptance.

Research Category: Post-Harvest Technology

Abbreviations

OD = Osmo dehydration; RSM = Response Surface Methodology; KMS = Potassium Meta Bisulphite; ºB = Brix; BI = Browning Index; mm = Milli Meter; N = Newton; % = Percentage; ºC = Celsius; TSS = Total Soluble Solids

Acknowledgement / Funding: Author thankful to Kerala Agricultural University, Thiruvananthapuram, 695522, Kerala. Authors also thankful to M.S. Sanjeev, Principal Scientist, Division of Crop Utilisation, ICAR - Central Tuber Crop Research Institute, Thiruvananthapuram, 695017, Kerala.

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Research project name or number: MSc Thesis

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors

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