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Effect of various pretreatments on dehydration of onion

Chetan Kumar Nagar, RC Verma, GP Sharma and AK Chittora

Abstract
Onion was pretreated with citric acid (CA), potassium metabisulphite (KMS) and NaCl for different pretreatment levels and dried in mechanical tray dryer at 50 ºC temperature. The quality parameters of dried onion *viz*. rehydration ratio, pyruvate content and colour (L, a and b) was analysed and the process variables were optimized by I-optimal technique of multiple regression used. In pretreated onion samples, drying period was minimum 680 min at 0.5 percent KMS pretreated level while it was minimum 1000 min at 20 per cent NaCl pretreatment level for drying upto 8 % (db) moisture content. Moisture diffusivity of pretreated onion samples ranged from 1.09 × 10-8 to 1.72 × 10-8 m2/s. The rehydration ratio of CA, KMS and NaCl pretreated onion was in the range from 3.76 to 4.06, 4.53 to 4.83 and 2.87 to 3.73 respectively. Pretreated onion with 0.75 per cent KMS had lighter colour (L = 85.9) than with other pretreatments while onion with 12.5 per cent NaCl showed was dark colour (L = 75.28). Similarly, yellowness was maximum (b = 28.32) for 5 per cent NaCl pretreatment. The pyruvate content ranged from 10.2 to 10.9, 11.9 to 12.8 and 9.8 to 8.6 µmol/g for CA, KMS and NaCl pretreated onions respectively.

Keywords: Moisture diffusivity, pyruvate content, i-optimal, colour, rehydration ratio

1. Introduction

Onion (*Allium cepa* L.) is also an important spice and vegetable crop grown all over world. India was the second largest producer of onion in 2017, when the world production of dried onions was 97.86 million tonnes, led by China and India producing 25 per cent and 23 per cent of the total, respectively (FAO, 2019) [1]. Indian onion is famous for its pungency and is available round the year. Onion contains vitamin B and traces of vitamin C, iron and calcium. Onions compared with other fresh vegetables are relatively high in food energy, intermediate in protein content and rich in calcium and riboflavin.

Onion is generally dried from an initial moisture content of about 86 per cent (w.b) to 7 per cent (w.b) or less for efficient storing, handling and processing. Dried onions in the form of flakes or powder are in great demand in few sections of the world, for instance UK, Japan, Russia, Germany, Netherlands and Spain. Fruits and vegetables are usually subjected to physical or chemical pretreatment before drying to shorten the drying time, reduce energy consumption and preserve the quality of products (Yu *et al*., 2017) [2]. Chemical pretreatment could significantly accelerate the drying process and remarkably improve the quality of dried products such as sweet potatoes, mushrooms, red pepper and plums (Xiao *et al.*, 2009) [3]. The present work has been undertaken to study the drying characteristics and quality parameters of onion with pretreatments.

2. Material and Methods

Fresh onion was procured from local market of Udaipur (Rajasthan). The onion and garlic were peeled manually using a stainless steel knife and sliced using food processor (approximate thickness 4 (±0.1) mm). The prepared samples were pretreated with chemicals before drying. The ratio of sliced onion and garlic to the pretreatment solution was maintained as 1:5. After soaking the samples were removed and blotted gently using tissue paper.

Table 1: Chemical pretreatments for onion

Pretreatment	Levels (%)	Soaking Duration (min)
Citric acid	0.5	10
	1.0	10
	1.5	10
KMS	0.5	20
	0.75	20
	1.0	20
NaCl	5	30
	12.5	30
	20	30

2.1 Initial moisture content

The moisture content of raw onion was determined before drying by using hot air oven method (AOAC, 2000) [4]. A small sample of 10g onion was kept in a pre-dried and pre- weighed moisture box placed in oven at 105 °C for 24 hours. The moisture content of sample was calculated by using following equation:

$$\text{Moisture content (w.b, per cent)} = \frac{W_1 - W_2}{W_1} \times 100 \quad \ldots (1)$$

Where,
W_1 = Mass of sample before drying, g
W_2 = Mass of sample after drying, g

2.2 Drying characteristics

2.2.1 Moisture content

Moisture content (db) of onion during drying was calculated (Brooker *et al*., 1997) [5] as:

$$\text{Moisture Content (db)} = \frac{W_\theta - DM}{DM} \times 100 \quad \ldots (2)$$

Where,
W_θ = Weight of sample at time θ, g
DM = Dry matter of the sample, g

2.2.2 Drying rate

The drying rate of sample was calculated by following mass balance equation (Brooker *et al*., 1997) [5].

$$R = \frac{\text{W ML (g)}}{\text{Time interval (min)} \times \text{DM (g)}} \quad \ldots (3)$$

Where,
R = Drying rate at time θ, g water/ g-min
WML = Initial weight of sample – Weight of sample after time θ
DM = Dry matter, g

2.2.3 Moisture diffusivity

The moisture diffusivity indicates the rapidness of flow of moisture within the material. Moisture diffusivity of the foods is influenced mainly by moisture content and temperature of the product (Karim and Hawaldar, 2005) [6].

For long drying periods, the equation A can be simplified to the first term of the series only (Celma *et al.*, 2005) [7] and results into eqn.

$$\ln\left(\frac{M - M_e}{M_o - M_e}\right) = \ln\frac{8}{\pi^2} - \left(\frac{\pi^2 D_e\ t}{L^2}\right) \quad \ldots (4)$$

Where,
MR = Moisture ratio, dimensionless
M_o = Initial moisture content, g water/g dry matter
M = Moisture content at any time, g water/g dry matter
M_e = Equilibrium moisture content, g water / g dry matter
D_e = Effective moisture diffusivity, m^2/s
L = Thickness of onion and garlic slices (0.004 m)
n = Positive integer
t = Time (s)
A plot of ln (MR) versus drying period gives a straight line with a slope B as,

$$\text{Slope} = \frac{(\pi^2 D_e)}{L^2} \quad \ldots (5)$$

The effective moisture diffusivity was determined by substituting values of slope B and thickness L in equation (5).

2.3 Quality evaluation

Quality is very important in food processing. In order to determine quality, dried samples were evaluated on the basis of several parameters *viz*. rehydration ratio, colour and pyruvate content.

2.3.1 Rehydration ratio

The rehydration ratio of onion and garlic samples was estimated as per AOAC (1990) [8] procedure. The sample weight before and after rehydration was calculated and from this rehydration ratio was determine as follows equation:

$$\text{Rehydration ratio} = \frac{W_r}{W_d} \quad \ldots (6)$$

Where,
W_r = Sample weight after rehydration, g
W_d = Sample weight before rehydration, g

2.3.2 Colour

Colour is important to consumer as a mean of identification, as a method of judging quality and for its basic esthetic value. The colour of the dried onion powder was measured using a Hunter Lab Colorimeter (Model CFLX/DIFF, CFLX-45). The 3D scale L, a and b values were used in Hunter Lab Colorimeter. In the Hunter scale, L measures lightness which varies from 0 (black) to 100 (white) on a vertical axis. The a is the degree of redness (+) and greenness (−) on a horizontal axis. The b measures yellowness (+) and blueness (−) on a secondary horizontal axis.

2.3.3 Pyruvate content

The pyruvate content is considered as an indicator of pungency in onion. The pyruvate as a measure for pungency was determined enzymatically by the L-lactate dehydrogenase (L-LDH) Schwimmer and Weston method (Schwimmer and Weston, 1961) [9]. The content was calculated on dry basis and expressed as micromole per 100 g solid.

2.4 Statistical analysis

For optimization of drying process of onion, I-optimal design was selected. In this design linear model is used for one variable which has different number of levels (Factor CA, KMS and NaCl pretreatment has three levels including 8 experiments run of each pretreatment separately for estimation of lack of fit. Numerical optimization technique was applied for pretreated onion samples for optimization of different range of input parameters (CA, KMS and NaCl) in terms of getting the optimum response *viz*., rehydration ratio, pyruvate content (µmol/g) and colour (L, a and b value).

3. Result and Discussion

3.1 Drying Characteristics of different pretreated onion

Initial moisture content of onion was determined by oven drying method was found to be 614.42 per cent (db). The initial moisture content of pretreated onion samples ranged from 609.52 to 708.64 per cent (db). Pretreated onion samples were dried in mechanical tray dryer at 50°C. The results of each drying experiment are presented in the following sections.

The moisture content of onion pretreated with 0.5 per cent CA was found to decrease from 649.37 to 6.90 (% db) in 860 min of drying while for 1.0 and 1.5 per cent pretreatment, it was found to decrease from 708.51 to 7.59 (% db) and 672.93 to 6.43 (% db) with drying period 840 and 820 min respectively (Fig. 1a).

The moisture content of onion pretreated with 0.5 per cent KMS was found to decrease from 708.64 to 7.21 (% db) in 680 min of drying while for 0.75 and 1.0 per cent pretreatment, it was found to decrease from 732.9 to 7.43 (% db) and 686.88 to 5.58 (% db) with drying period 720 and 780 min respectively (Fig. 1b).The moisture content of onion pretreated with 5 per cent NaCl was found to decrease from 650.0 to 6.15 (% db) in 780 min of drying while for 12.5 and 20 per cent pretreatment, it was found to vary from 625.96 to 5.48 (% db) and 609.52 to 7.59 (% db) with drying period 880 and 1000 min respectively (Fig. 1c).

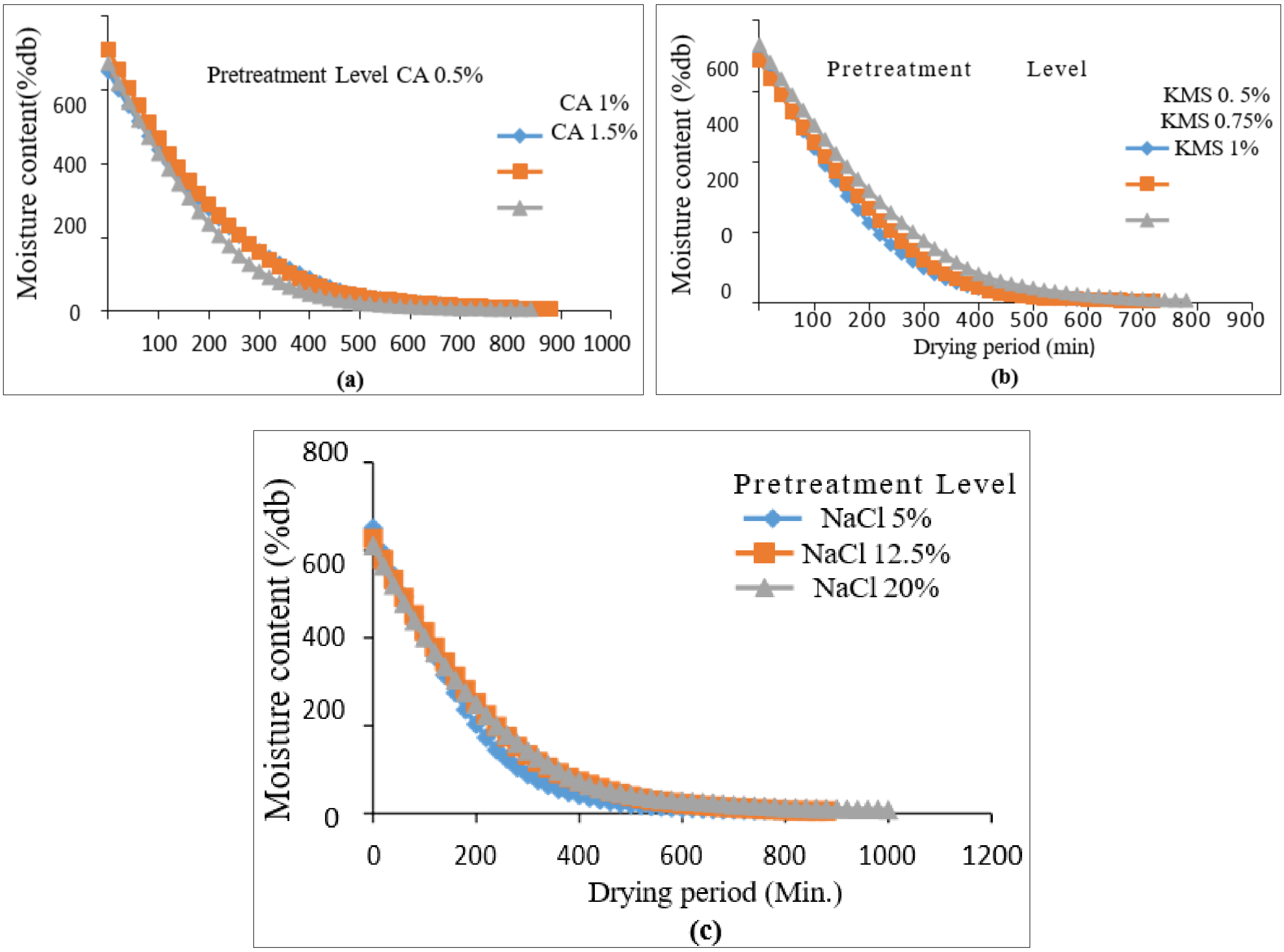

Fig 1(a, b, c): Variation in moisture content of onion with drying period at different levels of pretreatment with CA, KMS and NaCl

The drying period of various pretreated onion was compared to a uniform moisture content level i.e. 8 (% db). The drying period was found to be 810, 780 and 730 min for 0.5, 1.0 and 1.5 per cent CA pretreated onion. The total drying period was decreased with increase in pretreatment levels. The drying period was maximum 810 min for 0.5 per cent pretreatment level while it was minimum 730 min for 1.5 per cent pretreatment level (Table 2).

The drying period was found to be 610, 620 and 730 min for 0.5, 0.75 and 1.0 per cent KMS pretreated onion to 8 (% db) moisture content. It can be observed that drying period increased with increase in KMS pretreatment levels. The maximum drying period was found to be 730 min for 1.0 per cent KMS pretreatment level while it was minimum 610 min for 0.5 per cent pretreatment level (Table 2).

The drying period was found to be 670, 770 and 920 min for 5, 12.5 and 20 per cent NaCl pretreated onion to 8 (% db) moisture content. Drying period was found to increase with increase in NaCl pretreatment levels. The maximum drying period was found to be 920 min for 20 percent pretreatment level while it was minimum was 670 min for 5 per cent pretreatment level (Table 2). The moisture removal curves of NaCl pretreated samples were in good agreements with data reported by Shahade *et al.*, (2015) [10].

Table 2: Comparison of drying periods of onion for different pretreatment levels up to 8 percent moisture content (db)

Pretreatment	Levels (%)	Soaking Duration (min)	Drying period (min.)
Citric acid	0.5	10	810
	1	10	780
	1.5	10	730
KMS	0.5	20	610
	0.75	20	620
	1	20	730
NaCl	5	30	670
	12.5	30	770
	20	30	920

3.2 Effect of various pretreatments on drying rate of onion

The drying rate for the pretreated onion was estimated from the difference in its moisture loss in a known time interval.

Drying rate was found to be reduced from 1.468 to 0.004 g w/g dm-h with decrease in moisture content from 649.37 to 6.80 (% db) for 0.5 per cent CA pretreated onion. The drying rate was found to be reduced from 1.589 to 0.06 g w/g dm-h with decrease in moisture content from 708.51 to 7.59 (% db) for 1.0 per cent CA. Similarly, drying rate was found to be reduced from 1.637 to 0.04 g w/g dm-h with decrease in moisture content from 672.93 to 6.57 (% db) for 1.5 per cent CA pretreated onion (Fig. 2a).

The drying rate was found to be reduced from 1.716 to 0.006 g w/g dm-h with decrease in moisture content from 708.64 to 7.43 (% db) for 0.5 per cent KMS pretreated onion. Similarly, the drying rates were found to be reduced from 1.51 to 0.002 and 1.498 to 0.006 g w/g dm-h with decrease in moisture content from 686.88 to 6.88 and 732.29 to 7.43 (% db) for 0.75 and 1.0 per cent KMS pretreated onion respectively (Fig 2b).

In case of NaCl pretreated samples drying rate was found to be reduced from 1.713 to 0.004, 1.442 to 0.004 and 1.394 to 0.006 g w/g dm-h with decrease in moisture content from 650 to 6.15, 625.96 to 5.48 and 609.52 to 7.49 (% db) for 5, 12.5 and 20 per cent NaCl pretreatment pretreated onion respectively (Fig. 2c). These drying rates continuously decreased with decrease in moisture content (%db).

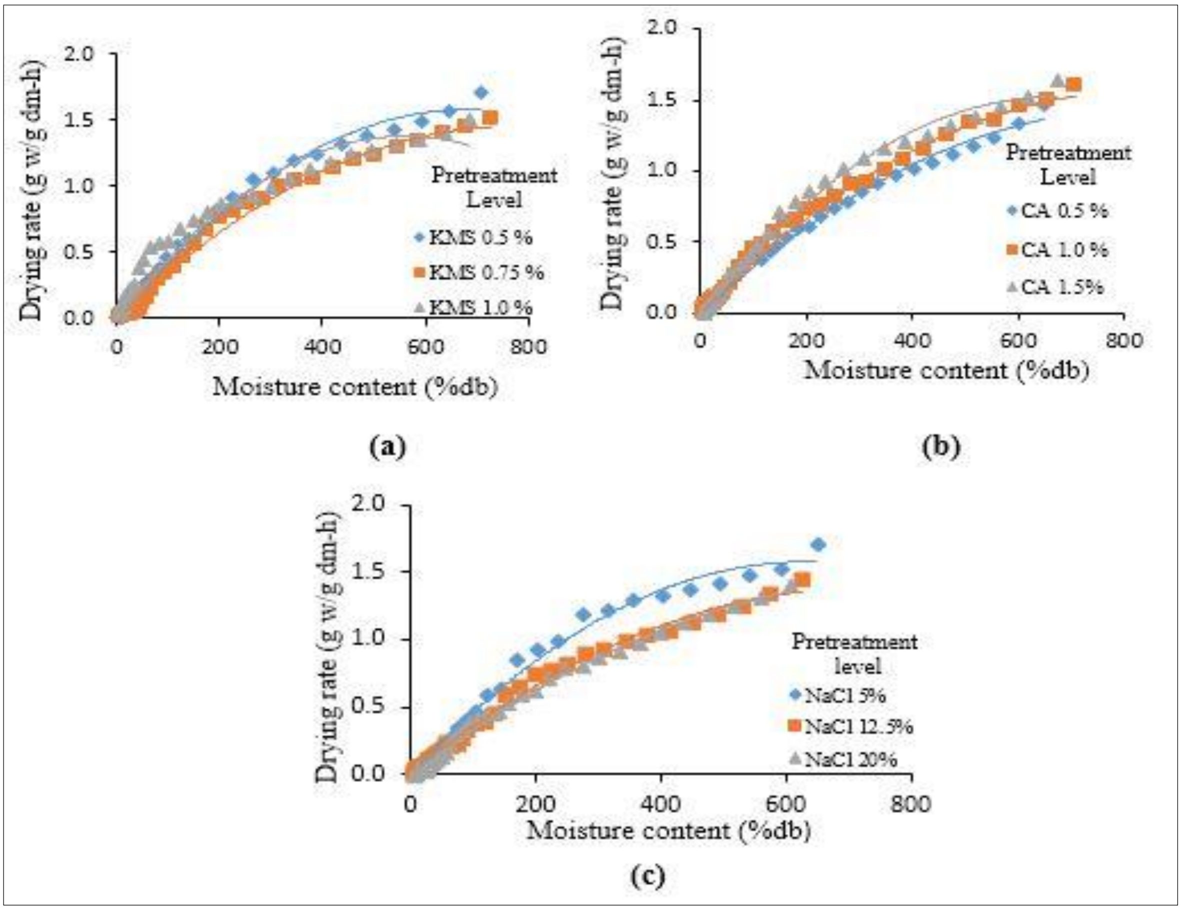

Fig 2 (a, b, c): Variation in drying rate of onion with moisture content at different CA, KMS and NaCl pretreatment levels

The drying rate of CA pretreated onion at initial stage of drying was found to be 1.468, 1.589 and 1.637 g-water/ g-dm-h for 0.5, 1.0 and 1.5 per cent pretreatment levels respectively. The maximum drying rate was 1.637 g-water/ g-dm-h observed for 1.5 per cent pretreatment level. The drying rate of KMS pretreated onion at initial stage of drying was found to be 1.716 1.51 and 1.498 g-water/ g-dm-h for 0.5, 0.75 and 1.0 per cent pretreatment levels respectively. The maximum drying rate was 1.716 g-water/ g-dm-h observed for 0.5 per cent pretreatment level.

Similarly, drying rate of NaCl pretreated onion at initial stage of drying was found to be 1.713, 1.442 and 1.394 g-water/ g-dm-h for 5, 12.5 and 20 per- -cent pretreatment levels respectively. The maximum drying rate was 1.713 g-water/ g-dm-h observed for 5 per cent pretreatment level.

3.3 Effect of different pretreatments on moisture diffusivity of onion

Effective moisture diffusivities are typically determined by plotting experimental drying data in terms of ln (MR) versus drying period (Lomauro *et al*., 1985; Tutuncu and Labuza, 1996) [11-12]. The moisture loss data during mechanical tray drying were analysed and moisture ratios at various time intervals were determined.

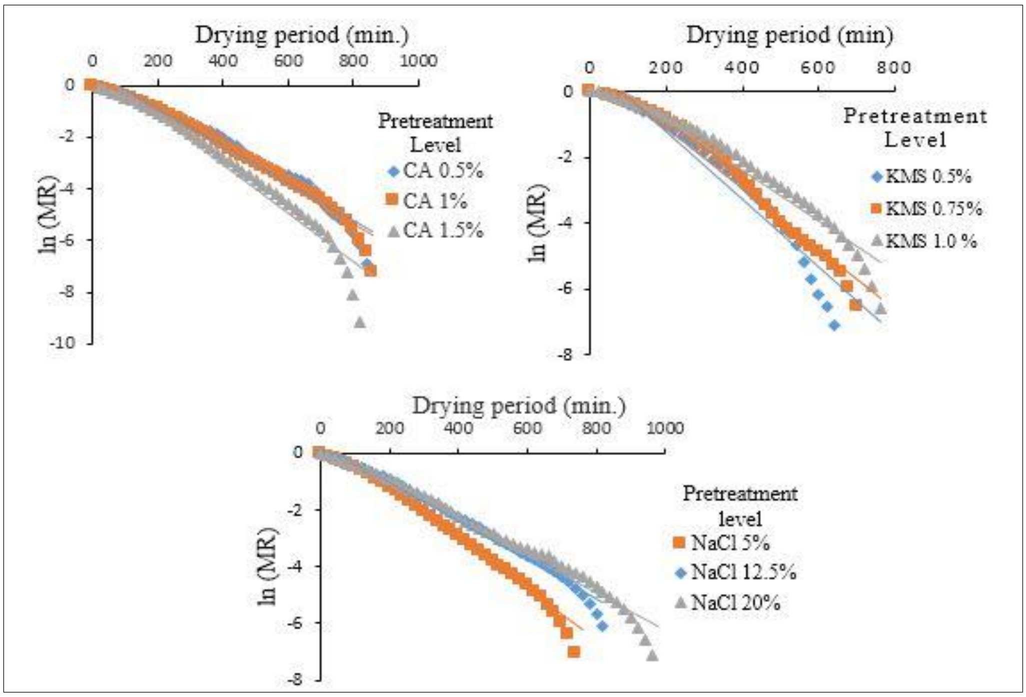

Fig 3: Variation in moisture ratio of onion with drying period at different CA, KMS and NaCl pretreatment levels

The variations in ln (MR) with drying period for each case was found to be linear with inverse slope, but at later stages of drying the curves did not follow the straight line. The moisture diffusivity of CA pretreated samples decreased from 1.52×10^{-8} to 1.16×10^{-8} m^2/s with increase in pretreatment levels from 0.5 to 1.5 per cent.

The moisture diffusivity of KMS pretreated onion decreased from 1.72×10^{-8} to 1.47×10^{-8} m^2/s with increase in pretreatment levels from 0.5 to 1.0 per cent pretreatment levels. Similarly, moisture diffusivity of NaCl pretreated samples increased from 1.09×10^{-8} to 1.42×10^{-8} m^2/s with increase in pretreatment levels from 5 to 20 per cent. Effective moisture diffusivity might have increased due to loosening of the surface cellular structure and leaching of some soluble components of the external cell layers of onion slices during soaking in osmotic solution.

3.4 Optimization of process parameters

As per one variable optimal model, 8 trials were performed for obtaining the rehydration ratio, colour (L, a and b), pyruvate content as responses for each pretreatment level condition in tray dryer. All these trials were replicated thrice and the average of the experimental data have been reported.

3.4.1 Effect of process variables on citric acid pretreated onion

The pretreatment levels during the drying were found to be Dependent on the different parameters and have been presented in Table 3.

Table 3: Observed parameters under different CA pretreatment levels

Run	CA (%)	Rehydration ratio	Pyruvate content (µmol/g)	Colour value		
				L	a	b
1	0.5	4.03	10.84	80.92	3.7	6.22
2	0.5	4.09	10.88	81.52	4.2	6.57
3	1	3.88	10.45	78.3	4.77	7.3
4	1.5	3.74	10.19	75.84	5.37	7.84
5	1.5	3.78	10.21	76.44	5.39	8.38
6	1	3.88	10.5	78.3	4.77	7.3
7	1	3.93	10.5	78.5	4.72	7.2
8	1	3.99	10.75	78.9	4.82	7.4

These data were analysed stepwise regression analysis as shown in Table 3. The linear model was fitted with the experimental data and statistical significance was calculated for rehydration ratio, pyruvate content and colour values (L, a and b) shown in Table 4. The lack of fit F value was non-significant which indicates that the developed model was adequate for predicting the response. This reveals that the non-significant terms have not been included in the model. Therefore, this model could be used to navigate the design space.

Table 4: ANOVA for responses of CA pretreated onion

Source	Rehydration ratio	Pyruvate content	Colour value		
			L	a	b
F value	49.01*	46.01*	232.91**	49.09**	76.20**
df	7	7	7	7	7
Lack of fit	0.092^{NS}	0.07^{NS}	0.54^{NS}	0.09^{NS}	0.099^{NS}
Std. Dev.	0.04	0.09	0.33	0.04	0.20
Mean	3.91	10.54	78.59	3.91	7.28
CV %	1.09	0.92	0.42	1.09	2.70
R^2	0.89	0.88	0.97	0.89	0.93
Adjusted R^2	0.87	0.86	0.97	0.87	0.91
Predicted R^2	0.82	0.84	0.95	0.82	0.82

**Significant at 1% level, * Significant at 5% level, NS- non significant

The result of analysis of variance indicated that the linear terms of rehydration ratio, pyruvate content are significant at 5% and colour value (L, a and b) significant at 1% (Table 4). In case of CA pretreated samples, for all the responses was less than 10%.

A model F-values of 49.01, 46.01, 232.91, 49.09 and 76.20 for rehydration ratio, pyruvate content and colour value (L, a and b) respectively implies that the model is significant.

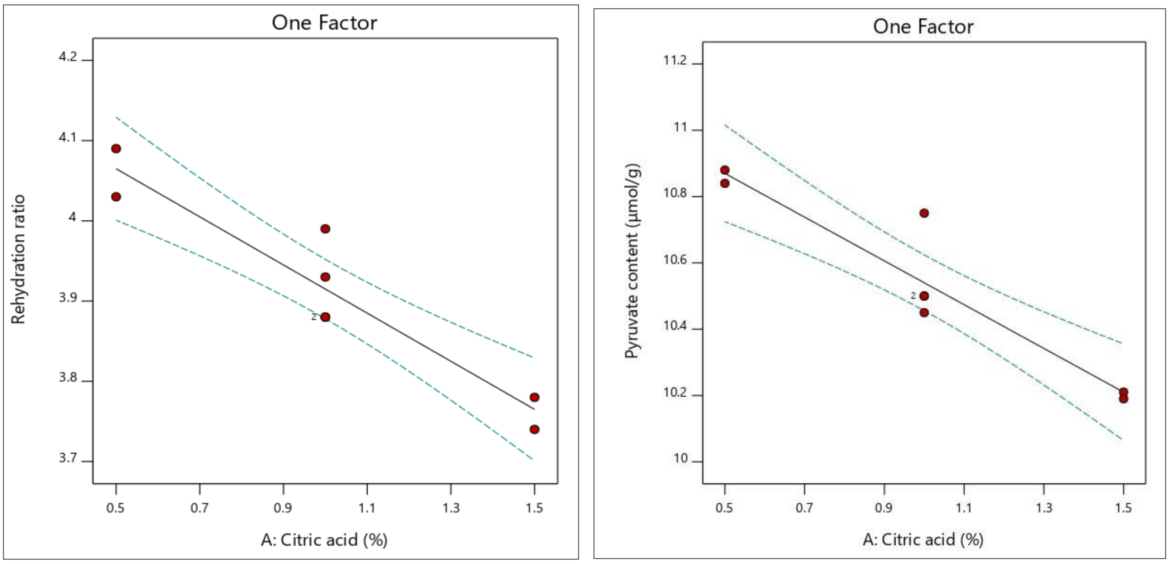

Fig 4: Effect of CA pretreatment levels on rehydration ratio and pyruvate content

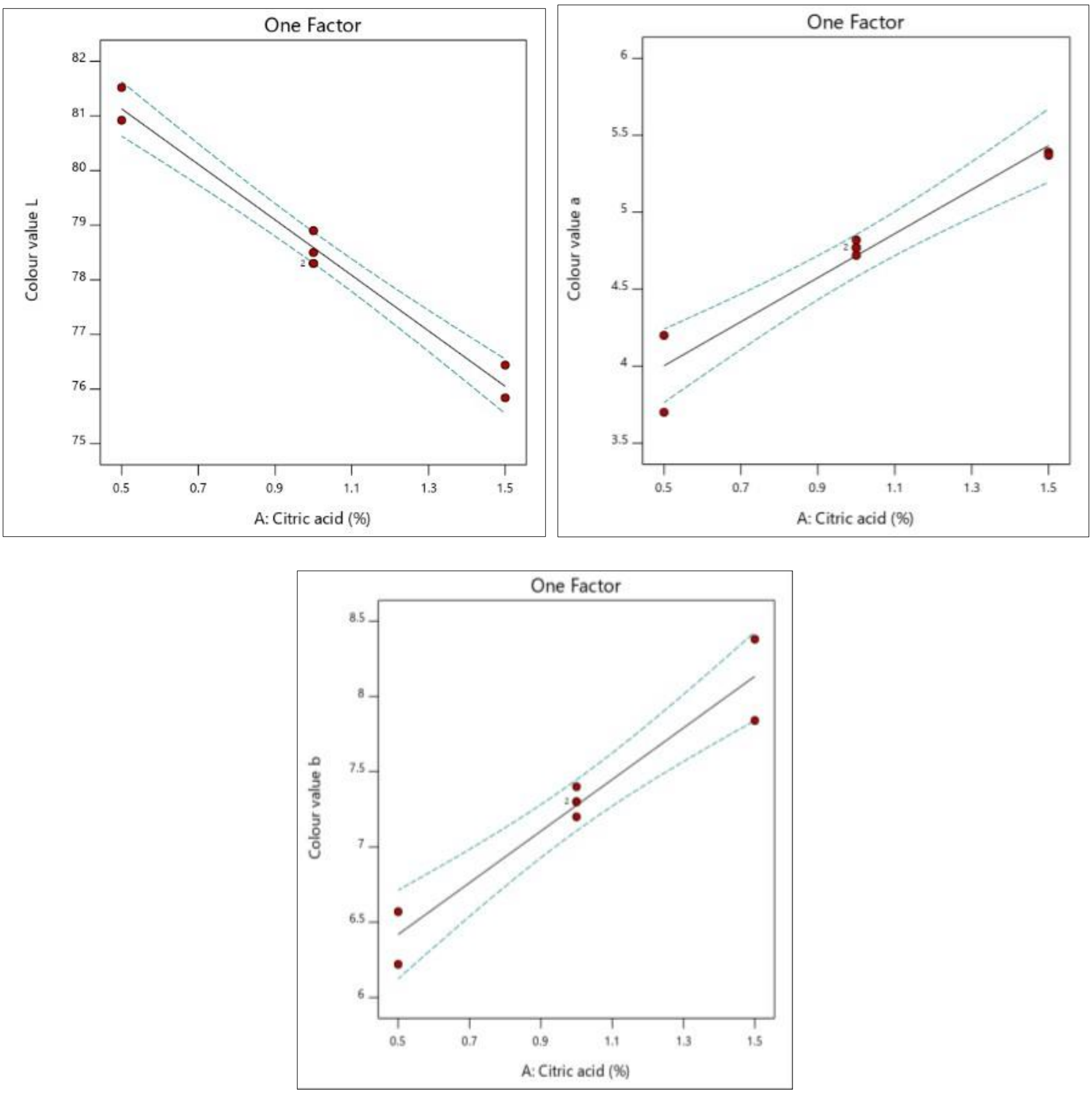

Fig 5: Effect of CA pretreatment levels on colour values L, a and b

The linear negative terms in above equations indicated that rehydration ratio, pyruvate content and colour value L decreased with increase in CA pretreatment level (Fig. 4) while colour values (a and b) increased with increase in CA pretreatment levels as presented in Fig. 5.

3.4.2 Optimization of process variables for CA pretreated onion

I-optimal optimization technique was carried out for the process parameter of the citric acid pretreated onion. The main criteria for constraints optimization were minimum drying time, maximum rehydration ratio, maximum possible pyruvate content and optimum values of L, a and b. In order to optimize the process parameter for drying of CA pretreated onion by numerical optimization this finds a point that maximizes the desirability function.

Table 5: Optimized values of CA pretreated onion

Citric acid (%)	Rehydration ratio	Pyruvate content	L	a	b	Drying time	Desirability
0.74	3.99	10.70	79.85	4.36	6.85	764.98	0.66

3.4.3 Effect of process variables on KMS pretreated onion

The process variables during the drying was found to be dependent on the KMS pretreatment levels and has been presented in Table 5.

Table 6: Observed parameters of KMS pretreated onion

Run	KMS %	Rehydration ratio	Pyruvate Content (µmol/g)	Colour value		
				L	a	b
1	1	4.85	12.75	85.6	1.35	7.6
2	0.75	4.68	12.4	81.35	2.07	8.7
3	0.5	4.5	11.8	76.65	2.75	9.98
4	0.75	4.68	12.4	81.35	2.07	8.7
5	0.75	4.7	12.45	81.4	2.1	8.8
6	0.5	4.56	12	77.25	2.95	10.18
7	1	4.91	12.75	86.2	1.55	7.86
8	0.75	4.74	12.45	81.9	2.16	9

These data were analysed by using stepwise regression analysis as shown in Table

3.5 The lack of fit F value: Was non-significant which. Indicates that the developed model was adequate for predicting the response. Therefore, this model could be used to navigate the design space.

Table 7: ANOVA for responses of KMS pretreated onion

Source	Rehydration ratio	Pyruvate content (µmol/g)	Colour value		
			L	a	b
F value	121.48**	102**	419.81**	233.33**	243.91**
df	7	7	7	7	7
Lack of fit	0.04^{NS}	4.44^{NS}	0.10^{NS}	0.55^{NS}	0.97^{NS}
Std. Dev.	0.032	0.08	0.31	0.09	0.15
Mean	4.70	12.37	81.46	2.13	8.85
CV %	0.675	0.68	0.38	4.31	1.70
R^2	0.95	0.94	0.99	0.97	0.98
Adj-R^2	0.94	0.93	0.99	0.97	0.97
Pred-R^2	0.90	0.87	0.98	0.94	0.85

*Significant at 1% level, NS- Non significant

The result of analysis of variance indicated that the linear terms of rehydration ratio, pyruvate content and colour value (L, a and b) are significant at 1%. (Table 7). The F- values of 121.48, 102, 419.81, 233.33 and 243.91 for model are rehydration ratio, pyruvate content and colour value (L, a and b) respectively implies that the model is significant.

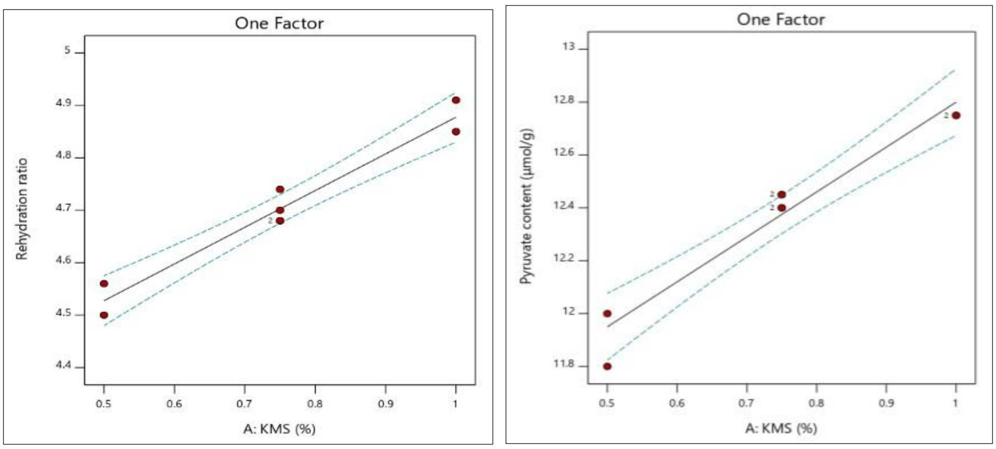

Fig 6: Effect of KMS pretreatment levels on rehydration ratio and pyruvate content

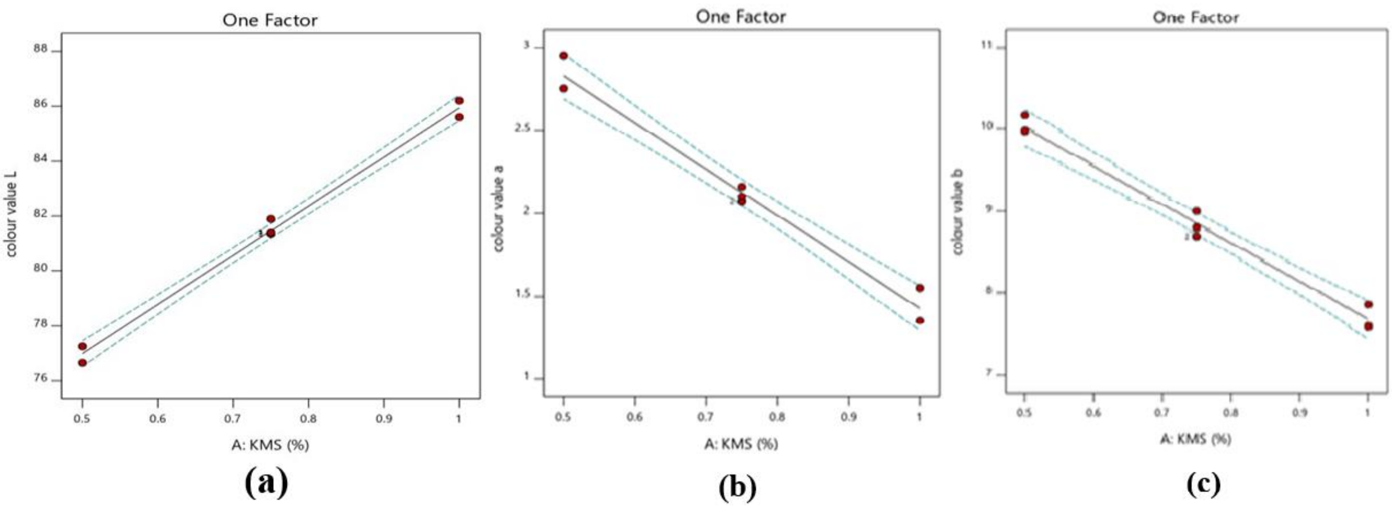

Fig 7 (a, b, c): Effect of KMS pretreatment levels on colour values a and b

The linear negative terms in above equations indicated that rehydration ratio, pyruvate content and colour value L increased with KMS pretreatment level (Fig 6 & 7a) and colour values (a and b) decreased with increase in pretreatment level presented in Fig. 7b & 7c.

Table 8: Optimized values of KMS pretreated onion

KMS (%)	Rehydration ratio	Pyruvate content	L	a	b	Drying time	Desirability
0.84	4.76	12.52	82.99	1.88	8.45	688.81	0.64

3.6 Effect of process variables on NaCl pretreated onion

The process variables during the drying was found to be dependent on the NaCl pretreatment levels and has been presented in Table 8.

Table 9: Observed parameters of NaCl pretreated onion

Run	NaCl (%)	Rehydration ratio	Pyruvate content (μmol/g)	Colour value		
				L	a	b
1	20	2.87	8.58	75.2	5.08	18.15
2	20	2.99	8.62	75.37	5.32	19.19
3	12.5	3.4	9.2	75.8	5.9	23.02
4	12.5	3.4	9.2	75.8	5.9	22.9
5	5	3.76	9.75	76.55	6.55	27.95
6	12.5	3.44	9.25	75.95	5.95	23.7
7	5	3.8	9.85	76.73	6.75	28.69
8	12.5	3.52	9.35	76.05	6.05	23.98

The linear model was fitted with the experimental data and statistical significance of linear terms was calculated for rehydration ratio, pyruvate content and colour values (L, a and b) shown in Table 9 (P<0.0001). The lack of fit F value was non-significant which indicates that the developed model was adequate for predicting the response.

Table 10: ANOVA for responses of NaCl pretreated onion

Source	Rehydration ratio	Pyruvate content (μmol/g)	Colour value		
			L	a	b
F value	135.26**	334.88**	131.91**	193.93**	337.92**
df	7	7	7	7	7
Lack of fit	4.11^{NS}	1.20^{NS}	0.52^{NS}	0.10^{NS}	0.06^{NS}
Std. Dev.	0.07	0.07	0.12	0.10	0.52
Mean	3.40	9.22	75.93	5.94	23.45
CV %	2.15	0.71	0.16	1.75	1.70
R^2	0.96	0.98	0.96	0.97	0.98
Adjusted R^2	0.95	0.98	0.95	0.96	0.98
Predicted R^2	0.92	0.97	0.92	0.93	0.97

Significant at 1% level, NS- non significant

The all result of analysis of variance indicated that the linear terms of rehydration ratio, pyruvate content and colour value (L, a and b) are significant at 1%. (Table 10). In case of NaCl pretreated samples, the coefficient of variation for all the responses were less than 10%. The F- values of 135.26, 334.88, 131.99, 193.93 and 337.92 for model are rehydration ratio, pyruvate content and colour value (L, a and b) respectively implies that the model is significant.

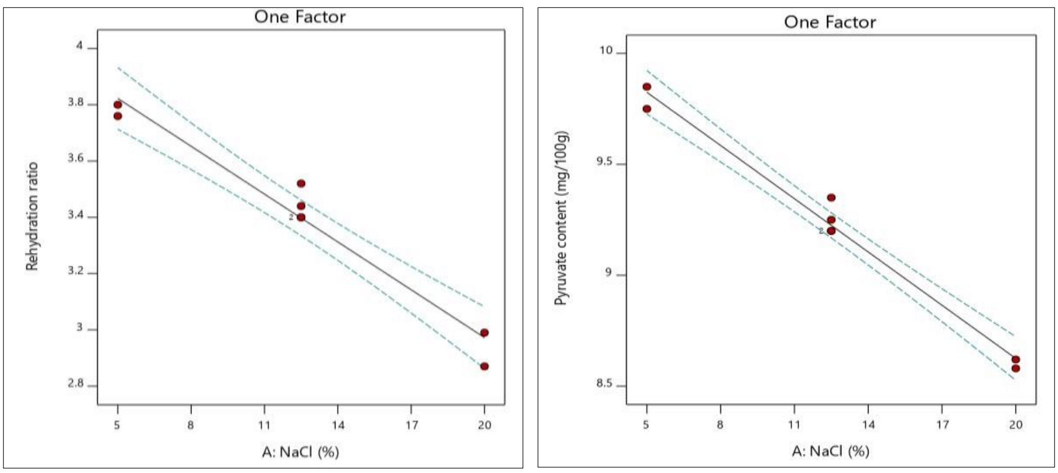

Fig 8: Effect of NaCl pretreatment levels on rehydration ratio and pyruvate content

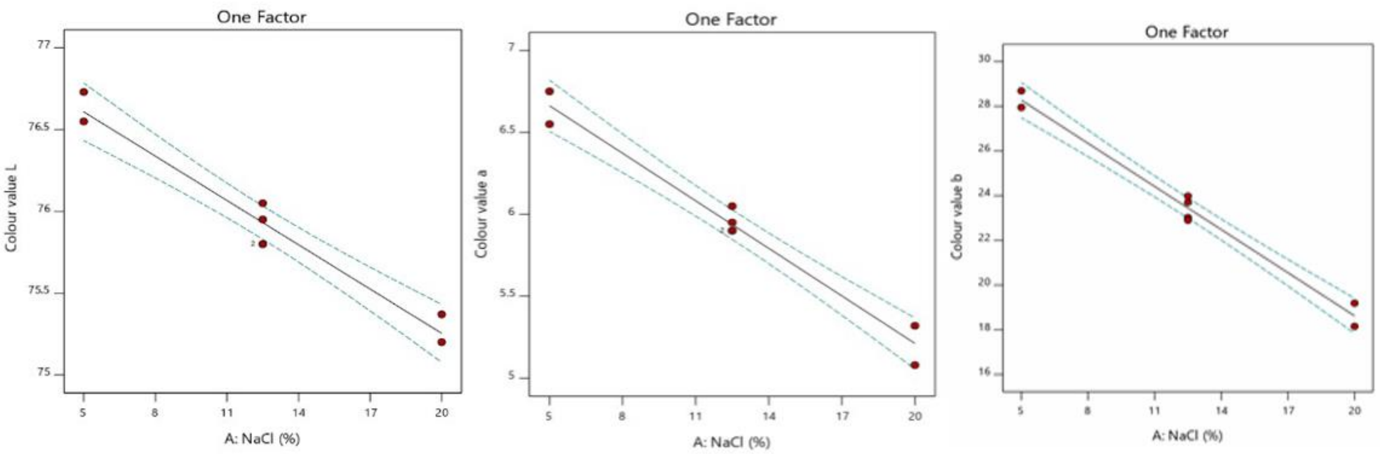

Fig 9: Effect of NaCl pretreatment levels on colour value L, a and b

The linear negative terms in above equations indicated that rehydration ratio pyruvate content and colour value (L, a and b) decreased with increase in NaCl pretreatment level (Fig. 8 & 9).

Table 11: Optimized values for NaCl pretreated onion

NaCl (%)	Rehydration ratio	Pyruvate content	L	a	b	Drying time	Desirability
7.12	3.70	9.65	76.41	6.45	26.89	707.03	0.74

4. Conclusion

Minimum drying period of pretreated onion was 610 min at 0.5 percent KMS pretreatment level. Moisture diffusivity of CA and KMS pretreated onion decreases with increase in pretreatment levels while increases with NaCl pretreatment levels. Rehydration ratio of pretreated onion decreases with CA and NaCl pretreatment levels while increases with KMS pretreatment levels. Pyruvate content in pretreated onion decreases with increases in CA and NaCl pretreatment levels while increases with KMS pretreatment levels. The maximum amount of pyruvate content found 12.8 µmol/g at 1 per cent KMS level. KMS pretreated onion samples found brighter than CA and NaCl pretreated samples. Among the different pretreatments, 0.84 per cent KMS pretreatment level for onion was found best because it had less drying time, maximum rehydration ratio, pyruvate content and brightness.

5. Reference

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