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Standardization of size/shape and pre-treating chemicals for dehydration of onion under solar tunnel dryer

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Abstract

An experiment for standardization of size/shape and pre-treating chemicals for dehydration of onion under solar tunnel dryer was conducted in the Department of Post Harvest Technology, College of Horticulture, Bagalkot, Karnataka during the year 2017-18. Fresh onion and tomatoes were prepared for dehydration by cutting into different size/shapes (S_1 - Dices and S_2 - Slices of onion) and subjected to different chemical pre-treatments for a specified duration. Onions and tomatoes thus prepared were dehydrated in solar tunnel dryer and analyzed for different physico-chemical qualities. In dried onion, the slices (S_2) recorded significantly minimum moisture content (13.80%), minimum drying time (57.17 hours), higher rehydration ratio (2.98) and significantly higher sensory score. Among pre-treatments, T_2 (0.25% KMS for 15 min), T_3 (0.1% KMS + 2% $CaCl_2$ for 5 min) and T_6 (0.5% $Na_2S_2O_5$ for 20 min) were found superior with respect to various physico-chemical and sensory properties.

Keywords: solar tunnel, pre-treating chemicals, size/shape, dehydration

1. Introduction

Onion (*Allium cepa*) is very important vegetable almost every Indian cousins do contain onion and are incomplete without it. Onion not only dominates in kitchen but also in export market, it is one of the major exporting vegetable from India. In India, Maharashtra is leading producer followed by Karnataka, Andhra Pradesh etc. Onion is well known for its antibacterial, anti fungal properties. It is rich in allyl propyl disulphide a sulphur containing compound has various nutraceutical benefits [1]. Having this much importance onion do suffer from problem of seasonal market glut and high variations in the market price which made the farmers return unpredictable. As a result farmers are in a fear to grow onion. To overcome this one of the alternative is to preserve the onions which are in excess or when the market price is very low by processing. Among various methods of processing technologies available drying is one of the oldest and cheapest methods of preservation [2]. Since the normal sun drying is an uncontrolled process the product is affected by varying atmospheric conditions and also permeable to damage by insects, rodents, birds etc. To overcome this one of the method followed is solar tunnel dehydration. In which the product is dehydrated safely inside an enclosed structure by utilising the renewable source of energy that is solar energy. As the product is protected from external environment it is of superior quality compare to solar dried product. The farmers in the area of our research were growing more of red coloured onion so the present study was conducted on red onion even though white onion were best for dehydration, by focusing on the loss incurred by local farmers this study was conducted with an objective to study the effect of pre-treatment and shape on physico-chemical qualities of onion dried using solar tunnel dryer.

2. Materials and Methods

2.1 Geographical location

The experiment was carried out in the Department of Post-Harvest Technology, College of Horticulture, Bagalkot, Karnataka during the year 2017-18. Geographically Bagalkot is located in northern dry zone (Zone-3) of Karnataka. The center is located at 75˚ 42˚ East longitude and 16˚ 10˚ North latitude with an altitude of 542 m above mean sea level (MSL).

2.2 Raw material

Red colored onions (variety Bhima Super) of medium size (40-100 g weight) were procured from UHS Haveli Farm, Bagalkot and brought to the Department of Post-Harvest Technology, College of Horticulture, Bagalkot. The fresh onions of uniform color, shape and medium size were selected, root and stem ends were removed and then skin was peeled manually using a sharp knife. Peeled onions were further cut into dices (15 mm×15 mm) and half-moon slices (0.5 cm) by using onion dicer cum slicer.

2.3 Solar tunnel dryer

A natural convection type dryer useful for bulk drying of agricultural and industrial products at moderate air temperature was employed in the experimentation. The structure consisted of a cylindrical metallic frame of size 30x15x10 feet covered with UV stabilized transparent polythene sheet of 200 micron thickness. The structure is positioned in N-S direction, with a door on south wall. The two exhaust fans located on front and back side of the tunnel assist to remove the moist air from the structure with a chimney on the top. The product intended for drying was uniformly spread on stainless steel trays (80x60x5 cm) which were kept on the metallic mesh stand inside the tunnel.

2.4 Treatment details

Treatments : 7
Replication : 3
Design : Factorial Completely Randomized Design
Sample size : 2 kg/treatment
Raw material : Bhima Super variety of red onion

Factor-1: Shape/thickness

S_1: Dices (15 × 15 mm)
S_2: Flakes/slices (0.5 cm)

Factor-2: Pre-treatments (Dipping)

T_1- Control
T_2- 0.25% KMS for 15 minutes
T_3- 0.1% KMS + 2% $CaCl_2$ for 5 minutes
T_4- 0.1% KMS + 0.5% K_2CO_3 for 5 minutes
T_5- 0.5% $NaHSO_3$ for 2 minutes
T_6- 0.5% $Na_2S_2O_5$ for 20 minutes
T_7- 0.5% Ascorbic acid for 5 minutes

Prepared onions (dices and slices) were dipped in solutions of above prescribed pre-treatments for specified period of time. Then they were drained and taken for dehydration in solar tunnel dryer.

2.5 Dehydration

A day before taking product into tunnel for drying, solar tunnel was fumigated with sulphur dioxide and stainless steel trays were swabbed with alcohol for disinfection purpose. Then pre-treated onions were dehydrated by spreading uniformly on clean disinfected stainless steel trays till reaching a safe moisture level of 15-20 per cent. The time required as influenced by different shapes and pre-treatments for drying of the product to reach the safe and optimum moisture level was recorded in hours.

3. Results and Discussion

3.1 Recovery (%)

Significant differences existed between the shapes (dices and slices) in respect of recovery (%) of dried onion. Dices (S_1) have recorded significantly maximum mean recovery per cent (12.87%) than slices (S_2-12.21%) (Table 1). Dry matter content determines the recovery [3] and it is a varietal character. As the variety tried with both the shapes was similar, the difference in recovery was not obviously because of dry matter. Dices (S_1) being thicker than the slices (S_2), moisture in dices needed to travel greater distance. Hence, the presence of comparatively higher moisture content in dices (S_1-16.00%) than slices (S_2-13.80%) could be attributed to higher recovery (%). Significantly maximum mean recovery per cent (13.32%) was recorded in T_2 (0.25% KMS for 15 minutes) which was statistically on par with T_3 (0.1% KMS + 2% $CaCl_2$ for 5 min) (12.52%) and T_6 (0.5% $Na_2S_2O_5$ for 20 min) (12.87%). Sulphur dioxide in the treatments involving KMS (T_2 and T_6) has been reported to bring about inactivation effect on pectin esterase enzyme. This in turn is expected to affect the textural property of material to be dried resulting in reduced osmotic loss of solutes during dipping pre-treatment [4]. Higher recovery recorded in case of treatment T_3 might be due to higher final moisture content. This may be caused probably due to hygroscopic nature of salt (KCl) coming from dipping solution forming crystals in the cellular compartments of tissue. It may increase bound water in the tissue which is difficult to remove [5]. Thus, significantly maximum recovery per cent due to interaction effect was associated with S_1T_6 (14.07%) and it was on par with S_1T_2 (13.43%).

3.2 Drying time (Hours)

In this study, pre-treatments, shapes and their interactions were found to significantly affect the drying time of onion. Between the shapes, slices (S_2-57.17 hours) dried significantly faster than dices (S_1-79.17 hours) (Table 1). As the thickness of sample increases, the drying time also increases on account of longer distance to be travelled by moisture [6]. The rate of drying process for a produce depends on composition of raw materials, size, shape and arrangement of produce, temperature, humidity and velocity of air, pressure and heat transfer to the surface [7]. Among pre-treatments, significantly minimum mean drying time (54.17) was recorded in T_7 (0.5% Ascorbic acid for 5 minutes). Ascorbic acid being an organic acid enters the living tissues in un-dissociated form and has the capacity to produce H^+ ions and other free radicles which affect the cellular permeability and increase movement of the moisture through cell membranes [8]. This phenomenon might account for decreased time taken by the treatment T_7.

3.3 Moisture (%)

During the period of drying operation a reduction in the moisture content of fresh onion (87.5%) was witnessed. Between shapes, significantly minimum mean moisture content value was recorded for slices (S_2-13.80 %) and the maximum mean value was recorded in dices (S_1-16.00 %) (Table 2). This might be attributed to larger surface area of slices and shorter distance to be travelled by moisture to evaporating surface in them (S_2). Pre-treatments did not show significant differences for moisture content (%). However, minimum and maximum values were recorded in T_1 (13.87%) and T_3 (16.06%) respectively (Fig. 1). Upon dehydration 'K' (KMS) and 'Cl' ($CaCl_2$) in T_3 reassociate as KCl crystals inside the cellular compartments [5]. This causes some moisture to be held by KCl and prevents it from drying out resulting in higher moisture content in the samples of T_3.

Significant differences were observed in the interactions between pre-treatment and shape for moisture content (%). Significantly minimum moisture content recorded in S_2T_1 (Control) (12.98%) which was on par with all other treatments except S_1T_7. This might be due to combined effect of higher surface area of slices and absence of absorption of moisture in T_1 as it did not involve any dipping pre-treatment.

3.4 Pungency (µ moles pyruvic acid/g)

Onion has a characteristic flavour or aroma due to the presence of volatile substances comprised of sulphur compounds. During dehydration, temperature and time of drying strongly influence the flavour concentration in onion tissues [9, 10]. Fresh onions had pungency of 7.63 µ moles/g in terms of pyruvic acid. Upon dehydration, a decrease in pyruvic acid (µ moles / g) content was noticed in all the treatments. The decrement occurred during drying could be attributed to evaporation, oxidation, maillard reaction [11] and also due to loss of thiosulphates [10]. A significantly maximum mean value for pungency (µ moles/g) was recorded in dices (S_1-5.28) than slices (S_2-4.23) (Table 3). In intact tissue, the volatile compounds and alliinase enzymes are compartmented and they do not react. But upon disintegration of onion tissue, two molecules of flavour precursor (*S*-alkyl-

L-cysteine sulfoxide) undergo hydrolysis and produce two molecules of pyruvate and one molecule of thiosulfinate in the presence of alliinase enzyme [12]. However, the loss of pungency due to evaporation, oxidation, Maillard reaction [11] during dehydration of onions was significantly more in slices (S_2) owing to larger surface area than dices (S_1).

Significant differences were observed with respect to pre-treatments for pungency (µ moles pyruvic acid/g). Treatment T_6 (0.5% $Na_2S_2O_5$ for 20 min) recorded significantly maximum mean value (6.37) and it was statistically on par with T_2 (0.25% KMS for 15 minutes) (5.47) and T_3 (0.1% KMS + 2% $CaCl_2$ for 5 min) (5.05) (Table 3). This might be attributed to preservative action of sulphur dioxide present in T_6, T_2 and T_3 against Maillard reactions, oxidation and prevention of loss of thiosulphates [13]. The sulphur present in these chemical treatments (T_2, T_3 and T_6) may supplement and to some extent compensate the loss of thiosulphates. Among interactions, T_6 (0.5% $Na_2S_2O_5$ for 20 min) showed significantly maximum pungency (µ moles/g) values in both S_2 (6.43) and S_1 (6.30). This may be attributed to the effectiveness of $Na_2S_2O_5$ in reducing loss of pyruvic acid (µ moles/g) due to its action in preventing NEB, oxidation and evaporation during dehydration.

3.5 Rehydration Ratio

The rehydration characteristics of a dried product are widely used as indicators of its quality. Rehydration is a complex process that is influenced by both physical and chemical changes associated with drying and the treatments preceding dehydration [14]. Significantly maximum mean rehydration ratio was recorded in slices (S_2-2.98) than dices (S_1-2.27) (Table 3). Treatment T_2 (0.25% KMS for 15 min) recorded significantly higher mean rehydration ratio value (3.03) which was statistically on par with T_3 (0.1% KMS + 2% $CaCl_2$ for 5 min) (2.93) and T_6 (0.5% $Na_2S_2O_5$ for 20 min) (2.70). The action of sulphur dioxide on onions in T_2, T_3 and T_6 decreases the proportion of rupture and shrinkage of cellular components as there was a decrease in pectin esterase enzyme activity [4]. This in turn maintains the increased ability of dried tissues to absorb water during rehydration [15]. Among the interactions, significantly maximum rehydration ratio (3.60) was recorded in S_2T_2 (0.25% KMS for 15 min).

Table 1: Effect of different pre-treatments and shapes on recovery (%) and drying time (Hours) of dehydrated onion

Treatments	Recovery (%)			Drying time (Hours)		
	S_1	S_2	Mean	S_1	S_2	Mean
T_1	12.43^{bcd}	11.87^{d}	12.15^{b}	85.77^{ab}	51.17^{de}	68.47^{abc}
T_2	13.43^{ab}	13.20^{abc}	13.32^{a}	84.05^{ab}	66.67^{bcde}	75.35^{ab}
T_3	12.63^{bcd}	12.40^{bcd}	12.52^{ab}	77.00^{abc}	57.17^{cde}	67.08^{abc}
T_4	12.57^{bcd}	12.30^{bcd}	12.43^{b}	74.83^{ab}	51.17^{de}	63.00^{bc}
T_5	12.47^{bcd}	11.80^{d}	12.13^{b}	94.17^{a}	70.00^{bd}	82.08^{ab}
T_6	14.07^{a}	11.67^{db}	12.87^{ab}	77.38^{abc}	56.67^{cde}	67.03^{abc}
T_7	12.53^{bcd}	12.20^{cd}	12.37^{b}	61.00^{cde}	47.33^{e}	54.17^{c}
Mean	12.87^{a}	12.21^{b}		79.17^{a}	57.17^{b}	
For comparing the means	S E m ±	CD 1%		S E m ±	CD 1%	
Shapes (S)	0.16	0.44		2.97	8.25	
Treatments (T)	0.30	0.85		5.55	15.42	
Interaction (S×T)	0.43	1.18		7.85	21.82	

Note: Values in the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at *P*=0.01

T_1: Control S_1: Dices
T_2: 0.25% KMS for 15 minutes, S_2: Slices
T_3: 0.1% KMS + 2% $CaCl_2$ for 5 minutes
T_4: 0.1% KMS + 0.5% K_2CO_3 for 5 minutes
T_5: 0.5% $NaHSO_3$ for 2 minutes
T_6: 0.5% $Na_2S_2O_5$ for 20 minutes
T_7: 0.5% Ascorbic acid for 5 minutes

Table 2: Effect of different pre-treatments and shapes on moisture (%) and water activity (a_w) of dehydrated onion

Treatments	Moisture (%)		
	S_1	S_2	Mean
T_1	14.74^{ab}	12.98^{b}	13.87
T_2	16.95^{ab}	13.94^{ab}	15.45
T_3	16.99^{ab}	15.11^{ab}	16.06
T_4	15.76^{ab}	13.42^{ab}	14.59
T_5	15.59^{ab}	13.18^{b}	14.37
T_6	14.68^{ab}	14.65^{ab}	14.67
T_7	17.28^{a}	13.26^{b}	15.27
Mean	16.00^{a}	13.80^{b}	
For comparing the means	S E m ±		CD 1%
Shapes (S)	0.54		1.50
Treatments (T)	1.01		NS
Interaction (S×T)	1.43		3.97

Note: Values in the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at *P*=0.01

T_1: Control S_1: Dices
T_2: 0.25% KMS for 15 minutes, S_2: Slices
T_3: 0.1% KMS + 2% $CaCl_2$ for 5 minutes
T_4: 0.1% KMS + 0.5% K_2CO_3 for 5 minutes
T_5: 0.5% $NaHSO_3$ for 2 minutes
T_6: 0.5% $Na_2S_2O_5$ for 20 minutes
T_7: 0.5% Ascorbic acid for 5 minutes

Table 3: Effect of different pre-treatments and shape on rehydration ratio and pungency (µ moles pyruvic acid/g) of dehydrated onion

Treatments	Rehydration Ratio			Pungency (µ moles pyruvic acid/g)		
	S_1	S_2	Mean	S_1	S_2	Mean
T_1	2.07^{e}	2.69^{bcd}	2.38^{cd}	4.00^{def}	3.73^{def}	3.87^{c}
T_2	2.47^{cde}	3.60^{a}	3.03^{a}	6.07^{ab}	4.85^{bcd}	5.47^{ab}
T_3	2.44^{cde}	3.43^{a}	2.93^{ab}	5.77^{abc}	4.35^{de}	5.05^{ab}
T_4	2.32^{cde}	2.84^{bc}	2.58^{bcd}	4.67^{cd}	2.98^{f}	3.83^{c}
T_5	2.17^{de}	2.41^{cde}	2.29^{d}	4.33^{de}	3.23^{ef}	3.77^{c}
T_6	2.29^{cde}	3.11^{ab}	2.70^{abc}	6.30^{a}	6.43^{a}	6.37^{a}
T_7	2.18^{de}	2.68^{bcd}	2.43^{cd}	5.87^{abc}	3.98^{df}	4.93^{b}
Mean	2.27^{b}	2.98^{a}		5.28^{a}	4.23^{b}	
For comparing the means	S E m ±	CD 1%		S E m ±	CD 1%	
Shapes (S)	0.07	0.21		0.17	0.46	
Treatments (T)	0.14	0.40		0.31	0.86	
Interaction (S×T)	0.20	0.57		0.44	1.22	

Note: Values in the same superscripts with respect to pre-treatments are not significantly different by Duncan Multiple Range Test at *P*=0.01

T_1: Control S_1: Dices
T_2: 0.25% KMS for 15 minutes S_2: Slices
T_3: 0.1% KMS + 2% $CaCl_2$ for 5 minutes
T_4: 0.1% KMS + 0.5% K_2CO_3 for 5 minutes
T_5: 0.5% $NaHSO_3$ for 2 minutes
T_6: 0.5% $Na_2S_2O_5$ for 20 minutes
T_7: 0.5% Ascorbic acid for 5 minutes

4. Conclusion

In this experiment, seven different pre-treatments (T_1-Control,T_2 -0.25% KMS for 15 min, T_3-0.1% KMS + 2% $CaCl_2$ for 5 min, T_4-0.1% KMS + 0.5% K_2CO_3 for 5 min, T_5: 0.5% $NaHSO_3$ for 2 min, T_6-0.5% $Na_2S_2O_5$ for 20 min and T_7-0.5% ascorbic acid for 5 min) and two shapes (S_1-dices and S_2-Slices) were attempted for dehydration of onion using solar tunnel dryer to select the best treatment and shape. Significantly maximum recovery was associated with dices (S_1-12.87%) and in treatment T_2 (0.25% KMS for 15 min) (13.32%). Slices (S_2-57.17 hours) dried significantly faster than dices (S_1-79.17 hours) and treatment T_7 (0.5% Ascorbic acid for 5 min) recorded significantly minimum drying time (54.17). Significantly minimum moisture content was observed S_2T_1 (12.98%). Retention of pungency (µ moles/g) was significantly maximum in T_6 of both S_2 (6.43) and S_1 (6.30). Significantly higher rehydration ratio was recorded in S_2T_2 (3.60) which was statistically on par with T_3 (3.43) and T_6 (3.11) of S_2.

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