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DRYING OF ONION PASTE TO DEVELOP POWDERS BY FOAM-MAT DRYING PROCESS USING SOY PROTEIN AS FOAMING AGENT

Muhammad Farooq[1], M. Javed Iqbal[2], Rizwan Shukat[2], Moale Cristina[3] Naila Ilyas[4], Iftikhar Ahmed Solangi[1], Wang Yunyang[1✉]

[1]College of Food Science and Engineering, Northwest A&F University, Yangling, Shaanxi, 712100, PR China
[2]*Department of Food Technology National Institute of Food Science and Technology University, of Agriculture Faisalabad, Pakistan*
[3] Research Station for Fruit growing Constanta (RSFG) 907300 Valu Lui Traian Pepinierei Street, No 25, Romania
[4]Graduate School of Chinese Academy of Agricultural Sciences, Beijing 100081, China
✉*wyy10421@163.com*

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ABSTRACT

Onion (*Allium cepa*) is locally called piaz. It is a biennial, herbaceous, winter seasoned and cross-pollinated bulb crop belonging to Family *Alliaceae.* High moisture content of onion render it to be affected by microbial and enzymatic spoilage. Drying is a very effective way to preserve onion for a long time. Onion powder was prepared by foam mat drying technique in which onion paste was treated with different concentration of soy protein (0%, 4%, 8% and 12%) as foaming agent and Carboxyl methylcellulose (0.5%) as foam stabilizer and these were dried in hot air tray drier at different temperatures (55°C, 65°C and 75°C) with 3mm sheet thickness of onion foams. Effect of different concentration of foaming agent and drying temperature was studied on moisture loss drying rate of onion paste. Increase in concentration of foaming agent significantly increased the drying rate from 0.422± 0.169 (Control) to 0.744± 0.169 (soy protein). Foamed onion paste were dried faster than un-foamed which decreased the drying time of 5 hours for foamed onion paste at 65°C and 75°C. Foamed onion pastes were dried in 300, 240 and 300 min at 55°C, 65°C and 75°C temperature respectively, with 12 % concentration of soy protein as foaming agent while un-foamed pastes were dried in 600, 420 and 480 mints at 55°C, 65°C and 75°C temperature respectively. Soy protein 12% and 65°C drying temperature was found best for drying of onion paste to develop powder.

1. Introduction

Preservation of food has been a keen interest of human beings to increase the shelf life and to make the availability of food material for a long time. In the season fruits and vegetables are available in surplus amount and if these food materials are not preserved by any mean then it may result into wastage off these food materials. It is reported that in developing countries almost 40% of our agricultural products are wasted due to lack of proper processing, preservation and storage facilities for these produce (Lombard, *et al*., 2008). These food spoilages may come from many sources during harvesting, handling, processing and storage of foods but most important are microbial and chemical spoilages (Gram, *et al*., 2002). Vegetables are considered most susceptible to spoilage due to the microbial attack and various kind of chemical changes (Tournas. 2005). And if these spoiled foods which harbor a high load of microbes are consumed result in to several kind of human health complication because of foodborne pathogens in spoiled food materials (Abadias, *et al*., 2008). Different kind of the microbes highly dependent upon the availability of water and the vegetables containing higher water activity have much more chances to be spoiled because of these microorganisms.

Dehydration or drying is the most efficient way to reduce the water activity of these kind of vegetables to prevent their spoilage (Mayor, *et al*., 2004; Koc, *et al*., 2008). There are number of food preservation techniques such as canning, curing, fermenting or acidifying and dehydration. Among all of these dehydration is most important and widely used because of being cost effective in term of packaging, storage and transportation of food material (Chavan and Amarowicz. 2012). Dehydration is one of the oldest method of food preservation in which water is removed or made unavailable in food materials. As water is the main component of the food which is required for microbial and enzymatic activity, more over chemical reactions also take place in availability of water. So, that is a water activity of different vegetables which define their stability (Farkas. 2007).

Market value of dehydrated vegetables is increasing in many countries due their stability and longer shelf life as compare to fresh vegetables (Zhang *et al*., 2006). Vegetables are dried by application of heat which evaporate their water contents. There are different methods for drying of vegetables like as sun drying, freeze drying, microwave drying, vacuum drying and infrared drying. Vegetables have many compounds such as phenolic and vitamins and these compounds are very sensitive to high temperature that's why selection of the drying technique depends upon final quality of end product, cost and many others factors, which should be kept in mind during selection of appropriate drying technique (Sagar and Kumar. 2010). A new technique name as foam-mat drying which is highly suitable for those foods which are sticky, very viscous and sensitive to high temperature, variety of food material can be dried by this technique with minimum quality changes (Kadam *et al.*, 2010).

Many reserachers conducted experiments to study the foam-mat drying process for (Kadam *et al.*, 2012) pineapple, (Dehghannya *al.*, 2019) lime juice, (Sankat *et al*., 2004) banana, (Zheng *et al.,* 2009) black currant pulp and (Alakali*et al.,* 2009) mango pulp to develop powders. All they have found that drying with foaming treatment increased the drying rate and minimized the quality changes by decreasing the water activity of powders. Our present study is also about foam-mat drying of onion paste and to investigate the effect of different concentration of soy protein as a foaming agent on moisture loss and drying rate of onion paste.

2. Material and method

2.1. Procurement and preparation of raw material

Onions were purchased from a local vegetable market in Faisalabad, sorted for good quality without bruises, cuts and microbial attacks. Which were peeled off, washed and grinded with grinder and converted into paste in fruits and vegetable lab at National Institute of Food Science and Technology, University of Agriculture Faisalabad. Soy protein was purchased from a scientific store (Abdullha Traders) Faisalabad and used as a foaming agent in different concentration.

Figure. 1. Cutting of onion into pieces

Figure 2. Grinding of onion

Figure 3. Onion paste

2.2. Development of onion foams by soy protein

Onion paste weighing 200g was taken for each experiment and treated with different concentration of soy protein (0%, 4%, 8% and 12%) as foaming agent. Carboxyl Methyl cellulose (0.5%) was used as a foam stabilizer. Onion paste, foaming agent and foam stabilizer in determined concentration were mixed in a 1000ml beaker and beating was done for 3 minutes to increase surface area of onion paste by developing stable foams with incorporation of maximum amount of air in onion paste by using a small scale hand beater used in kitchen for beating of eggs.

2.3. Foam spreading in trays and drying

Foams of onion paste subjected to different concentration of soy protein (0%, 4%, 8% and 12%) as foaming agent were spread to 3mm sheet thickness on aluminum foils and placed in stainless steel trays. Commercially available hot air tray dryer (Model # R-5A, Serial # 10-213, Commercial dehydrator systems, Inc.) was used for drying experiment in fruits and vegetable lab at National institute of food science and technology, University of Agriculture Faisalabad, Punjab, Pakistan. Drying was carried out in 3 batches, first batch was dried at 55°C comprising on four samples, one (Controlled) not treated with any foaming agent while three others which were treated with 4%, 8% and 12% concentration of soy protein respectively. All the four samples were prepared again with same above mentioned concentrations of foaming agent and dried at 65°C and 75°C. During drying experiment after each 60 minutes' weight of all samples were recorded and when constant weight was appeared, all the samples from the dryer were removed and placed in desiccator.

Figure 4. Onion foams

Figure 5. Foam spreading in trays

Figure 6. Drying of onion foams in tray dryer

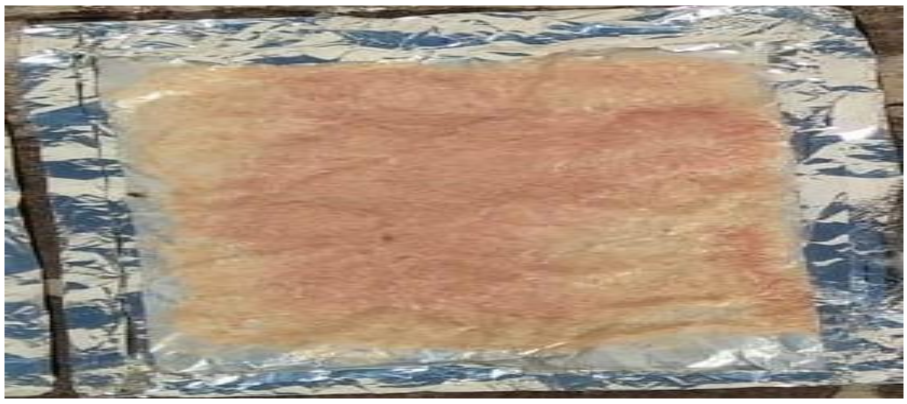

Figure 7. Dried onion foam sheet

2.4. Milling and storage of powder

All the samples were removed from the desiccator and grounded in a grinder to develop free flowing powders. All the samples were stored at room temperature in polythene bags.

Figure 8. Dried onion powder samples

2.5. Moisture loss and drying rate

During the drying experiments of onion foams developed by different concentration of soy protein as foaming agent at different drying temperatures. Weight of each sample was recoded after an hour by a weighing balance, which was used to determine the decrease in moisture content of onion foams during drying process. Initial moisture content in onion foams were calculated by AOAC. (2017) standard method of moisture calculation. Final moisture content of onion powders was also measured. By using the data of decrease in moisture of different samples drying rate was calculated by using $\Delta X/\Delta t$.

2.6. Drying curves

Drying curves for moisture loss and drying rate was plotted by using the data of moisture loss X from onion foams and drying rate $\Delta X/\Delta t$ verses time. Drying curves give information to know about exact drying time where these onion foams are dried. By these drying curves we can have idea about the best concentration of soy protein and temperature where sample dried in minimum time.

2.7. Physicochemical analysis of onion powder

Moisture content

Moisture content of all onion powder samples were determined by a standard method for moisture determination described by AOAC. (2017). 5g of powder sample was taken into known weight of china dish. China dish along with sample was placed in an oven for overnight at 105°C or till constant weight of sample. Then moisture content was calculated by following formula.

$$\text{Moisture content \%} = \frac{\text{Weight of fresh sample} - \text{weight of dried sample}}{\text{Weight of fresh sample}} \times 100 \quad (1)$$

2.8. Total Soluble Solids (TSS)

Refractometer was used for the measurement of Total soluble solid (°B, Degree brix) in foam-mat dried rehydrated onion powder samples.

Figure 9. Rehydrated onion powder samples

Fig. 10. Refractometer for total soluble solids determination

2.9. Water solubility index (WSI)

Solubility of the foam-mat dried onion powders was calculated by a method used by Flade and okocha. (2010). Solubility of onion powders which were developed by treatment of different concentration soy protein as foaming agent was determined at Food and Nutraceutical lab, Food Science department of University of Agriculture Faisalabad, Pakistan. Onion powder weighing of 2g was taken and dissolved in 20ml of distilled water by stirring for 3 mints. Then poured rehydrated onion powder solution into 20ml centrifuge tube and performed centrifugation for 3 mints at 3000 rpm. Then after centrifugation wet samples were dried in oven at 105°C.Dried samples were weighted and recorded. Weight of dried samples were used to calculated water solubility.

2.10. Water absorption index (WAI)

Water absorption capacity was determined by a method described by Falade, *et al.* (2010). Water absorption of onion powders was determined at Food and Nutraceutical lab, Food Science department of University of Agriculture Faisalabad, Pakistan. Onion powder weighing of 1.5g was taken and dissolved in 20ml of distilled water by stirring for 3 mints. Then poured rehydrated onion powder solution into 20ml centrifuge tube and performed centrifugation for 3 mints at 3000 rpm. Then after centrifugation wet samples were weighted and dried in oven at 105°C.Dried samples were weighted and recorded. Weight of dried samples were used to calculate water solubility.

2.11. Statistical analysis

The data of each parameter was analyzed by two-way ANOVA statistical analysis to determine the level of significance according to the method defined by Montgomery, (2008).

3. Results and discussions

Onion powder was produced by using soy protein in different concentration levels. Data for moisture loss for onion powders developed by different concentration levels of soy protein as foaming agent for which values are given in table 1, 2 and 3 which were used to draw drying curves for moisture loss which can be seen in fig. 11,12 and 13 for drying at 55°C, 65°C, and 75°C. From the available data it was observed that moisture content decreased with time. Analysis of variance (ANOVA) showed highly significant effect of foaming agent and temperature ($P<0.01$). Foaming treatment resulted in faster drying as compare to non-foamed onion paste drying. Drying was fast for all above experiments in which foaming agents was used. Initially 200g onion paste sample was taken which contained 184g of moisture content and dried to achieve constant weight in try drier at 55°C, 65°C and 75°C. At 55°C onion paste without foaming agent (Control) take 10 hours to dry while onion pastes subjected to different concentration of soy protein dried faster and saved 5 hours which can be seen in table 1. As foaming treatment increases the surface area for drying which is resulted in better and faster removal of moisture content from onion paste. While removal of moisture from un-foamed onion paste was slow because of dense structure which resulted in slow moisture reduction. Increase in concentration of foaming agent resulted in faster drying. Fastest drying of onion paste at 55°C was observed for 12% concentration of soy protein as foaming agent. As indicated in fig. 11, 12 and 13 increase in temperature resulted in significantly drop in moisture content of onion powders.

Dehghannya. (2019); Kadam *et al.*, (2011) reported similar results. In this research descending trend in moisture content of onion powders were observed with increase in temperature for which values are given in table 1, 2 and 3. Drying rate was calculated and used to draw drying rate curves for which data is given in table 4, 5 and 6. Drying rate for the onion powder at 55°C, 65°C and 75°C were evaluated by drying curves shown in fig. 14, 15 and 16 for drying at 55°C, 65°C and 75°C. Drying curves were drawing with the data on the rate of drying versus time. Falling rate period was observed with passage of time because in start of the drying onion paste contains very high water content while with the passage of time during drying water content decrease and it became hard to remove moisture from inside of the sample. Hence, drying rate decreases with time. Mean values for drying rate of onion paste dried at 55°C, 65°C and 75°C by using different concentration of soy protein (4%,8% and 12%) as foaming agents are given in table 7. From the data it is shown that highest drying rate for soy protein 0.744± 0.169 at 65°C with 12% concentration.

Table 1. Moisture loss from onion paste drying at 55°C temperature using different concentration of soy protein as foaming agent

Drying of onion paste at 55°C temperature					
Sr.No.	**Time,t(min)**	**Moisture content , X (g moisture/g dry solid)**			
Treatments		**T_0 (Control)**	**T_1(SP=4%)**	**T_2 (SP=8%)**	**T_3 (SP=12%)**
1	0	183	183	183	183
2	60	154	143	135	123
3	120	127	112	101	73
4	180	105.3	82	67	36
5	240	84	62	44	8
6	300	64.7	42	21	0
7	360	48.4	24	0	
8	420	32	4		
9	480	18.5	0		
10	540	9			
11	600	0			

Table 2. Moisture loss from onion paste drying at 65°C temperature using different concentration of soy protein as foaming agent

Drying of onion paste at 65°C temperature					
Sr.No.	**Time,t(min)**	**Moisture content , X (g moisture/g dry solid)**			
Treatments		**T_0 (Control)**	**T_1 (SP=4%)**	**T_2 (SP=8%)**	**T_3 (SP=12%)**
1	0	183	183	183	183
2	60	143.2	135	123	121
3	120	109	95.12	81	78
4	180	78	55.7	42	35
5	240	53	19.7	6	0
6	300	31	0	0	
7	360	11			
8	420	0			

Table 3. Moisture loss from onion paste drying at 75°C temperature using different concentration of soy protein as foaming agent

Drying of onion paste at 75°C temperature					
Sr.No.	**Time, t (min)**	**Moisture Loss, X (g moisture/g dry solid)**			
Treatments		**T_0 (Control)**	**T_1 (SP=4%)**	**T_2 (SP=8%)**	**T_3 (SP=12%)**
1	0	183	183	183	183
2	60	140.3	125	121	113
3	120	113	93	85	71
4	180	88	63	53	35

5	240	67	39	25	6
6	300	46	15	0	0
7	360	26	0		
8	420	8			
9	480	0			

Table 4. Drying rate of onion paste at 55°C using different concentration of soy protein as foaming agent

Sr. No.	Time	Drying rate at 55°C, N (g/cm²min)			
Treatments		T_0 (Control)	T_1 (SP=4%)	T_2 (SP=8%)	T_3 (SP=12%)
1	0	0	0	0	0
2	60	0.453± 0.025	0.656± 0.012	0.790± 0.010	0.986± 0.015
3	120	0.423± 0.025	0.520± 0.020	0.560± 0.010	0.783± 0.042
4	180	0.350± 0.017	0.503± 0.015	0.563± 0.012	0.660± 0.035
5	240	0.346± 0.025	0.306± 0.021	0.380± 0.020	0.440± 0.017
6	300	0.330± 0.017	0.303± 0.023	0.393± 0.015	0.120± 0.017
7	360	0.286± 0.016	0.283± 0.015	0.350± 0.020	0
8	420	0.243± 0.025	0.330± 0.010	0	
9	480	0.193± 0.023	0.070± 0.010		
10	540	0.130± 0.026	0		
11	600	0.156± 0.011			
12	660	0			

Table 5. Drying rate of onion paste at 65°C using different concentration of soy protein as foaming agent

Sr. No.	Time	Drying rate at 65°C , N (g/cm²min)			
Treatments		T_0 (Control)	T_1 (SP=4%)	T_2 (SP=8%)	T_3 (SP=12%)
1	0	0	0	0	0
2	60	0.650± 0.010	0.806± 0.020	1.013± 0.015	1.006± 0.020
3	120	0.570± 0.010	0.630±0.026	0.650± 0.026	0.710± 0.017
4	180	0.503± 0.015	0.663± 0.005	0.626± 0.025	0.693± 0.023
5	240	0.423± 0.050	0.593± 0.005	0.610± 0.034	0.566± 0.011
6	300	0.346± 0.025	0.323± 0.030	0.596± 0.015	0
7	360	0.306± 0.020	0	0	
8	420	0.153± 0.025			
9	480	0			

Table 6. Drying rate of onion paste at 75°C using different concentration of soy protein as foaming agent

Sr.No.	Time	Drying rate at 75°C, N (g/cm²min)			
Treatments		T_0 (Control)	T_1 (SP=4%)	T_2 (SP=8%)	T_3 (SP=12%)
1	0	0	0	0	0
2	60	0.700± 0.010	0.970± 0.020	1.016± 0.011	1.143± 0.030
3	120	0.453± 0.011	0.516±0.023	0.600± 0.020	0.703± 0.015
4	180	0.436± 0.015	0.493± 0.011	0.523± 0.011	0.586± 0.011
5	240	0.340± 0.017	0.416± 0.015	0.473± 0.015	0.486± 0.005
6	300	0.333± 0.015	0.413± 0.032	0.416± 0.005	0.103± 0.015
7	360	0.296± 0.012	0.220± 0.030	0	0
8	420	0.136± 0.011	0		
9	480	0			

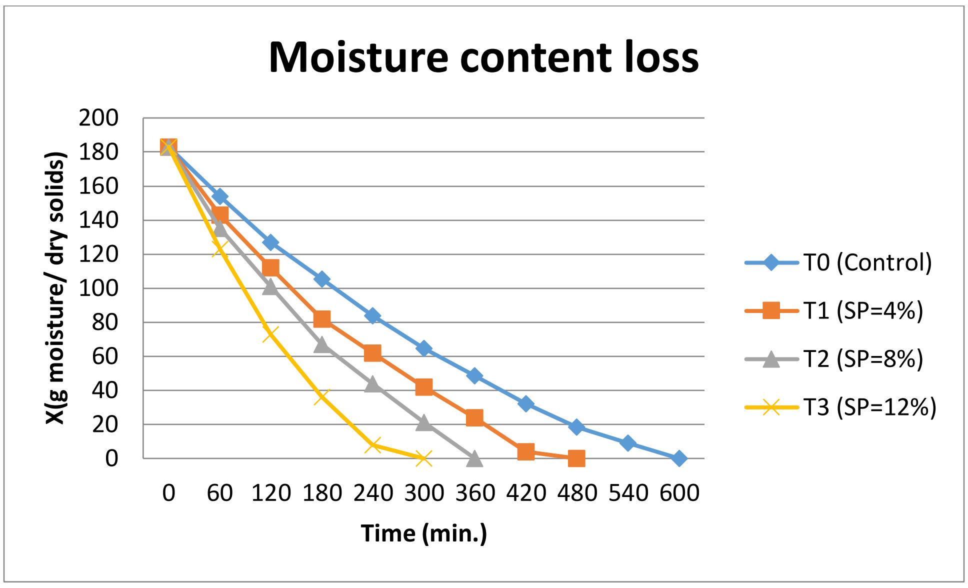

Figure 11. Effect of soy protein concentration level on moisture during foam mat drying of onion paste at 55°C.

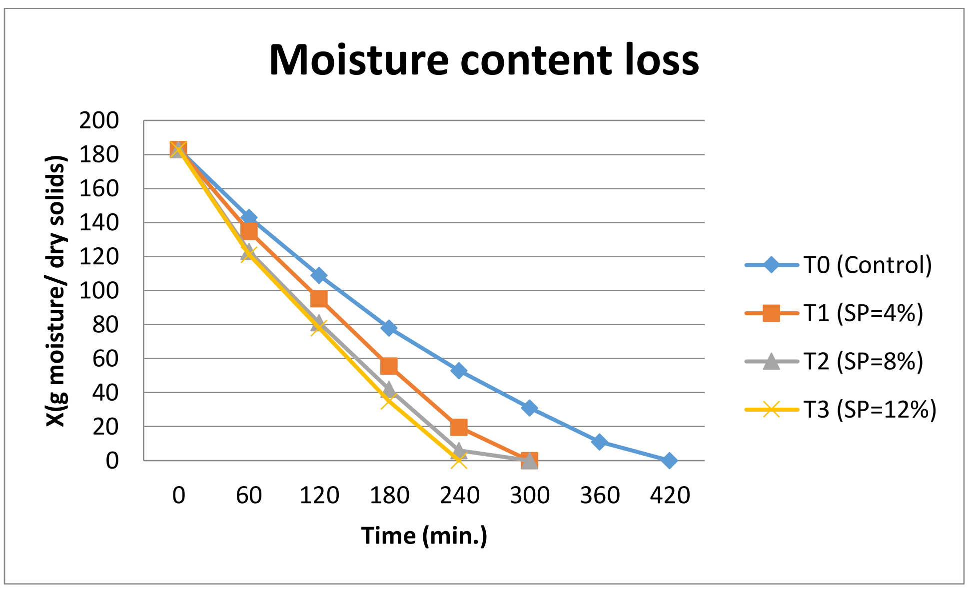

Figure 12. Effect of soy protein concentration level on moisture during foam mat drying of onion paste at 65°C.

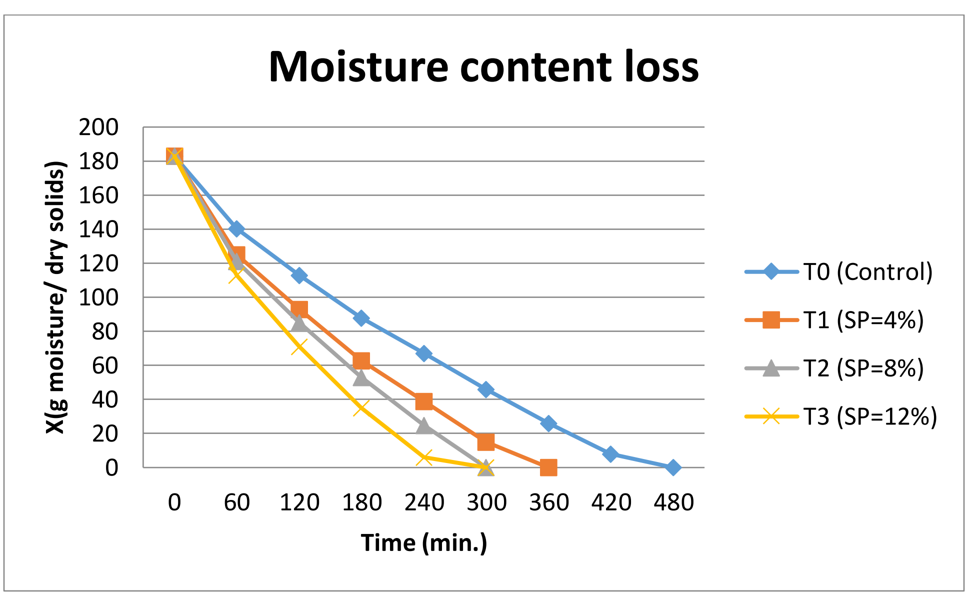

Figure 13. Effect of soy protein concentration level on moisture during foam mat drying of onion paste at 75°C.

3.1.Moisture of onion powder

In our daily life we always need to preserve food materials to make their availability throughout the year. Main purpose of food preservation is to prevent the food spoilage and maintain the nutritional characteristics of the food material. Spoilage can be caused by physical, chemical and microbial changes. But mostly chemical and microbial spoilage are most important. Most of chemical reactions take place in the water. Although all the microbes needed water to cause spoilage. Drying is a most important phenomena of food preservation to reduce the water content in our food material to keep them safe from chemical and microbial spoilage. Analysis of variance (ANOVA) showed significant effect ($p<0.05$) of foaming agent on moisture content of onion powder while temperature showed highly significant ($P<0.01$) effects on moisture content. Effect of soy protein concentration levels on final moisture content in onion powders developed through foam mat drying process at 55°C, 65°C and 75°C was significant. Kadam *et al*., (2011) reported similar results as in our present study. In that research a descending trend of moisture % was observed as temperature increased from 50°C to 70°C. Increase in concentration of soy protein resulted in decreasing moisture content of onion powder. For samples in which soy protein was used as foaming agent moisture content was 7.967± 0.266 and 4.593± 0.102 with 4 % and 12 % concentration at 65°C. From moisture data of foam mat dried onion powder 28.636± 0.474 was the highest value of moisture content at 55°C in control sample (un-foamed) and 4.593± 0.102 was lowest value at 75°C in T3 sample treated with 12% soy protein as a foaming agent. Hence, temperature influenced the moisture content very significantly for soy protein treatments.

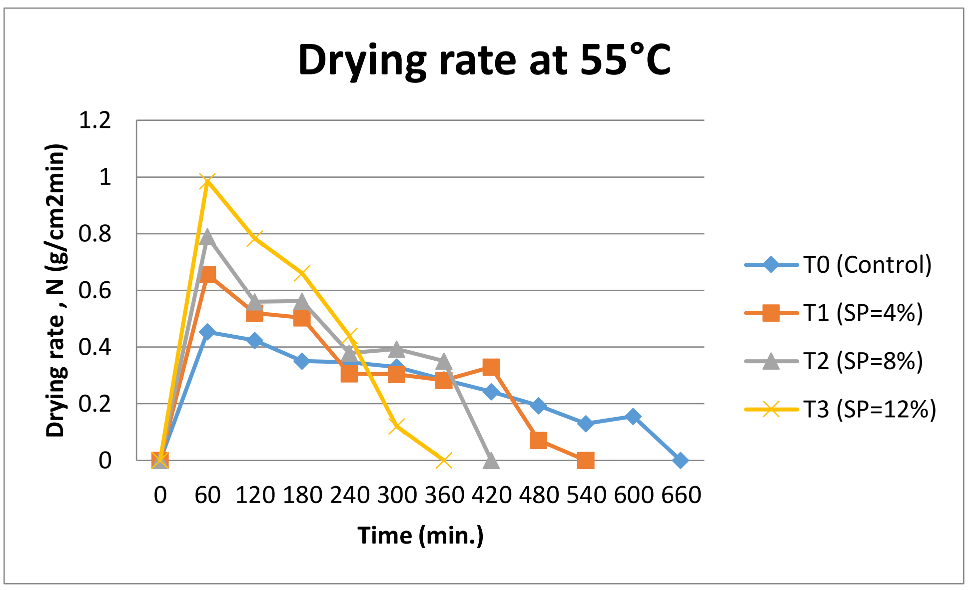

Figure 14. Effect of soy protein concentration level on drying rate of foam mat dried onion paste at 55°C.

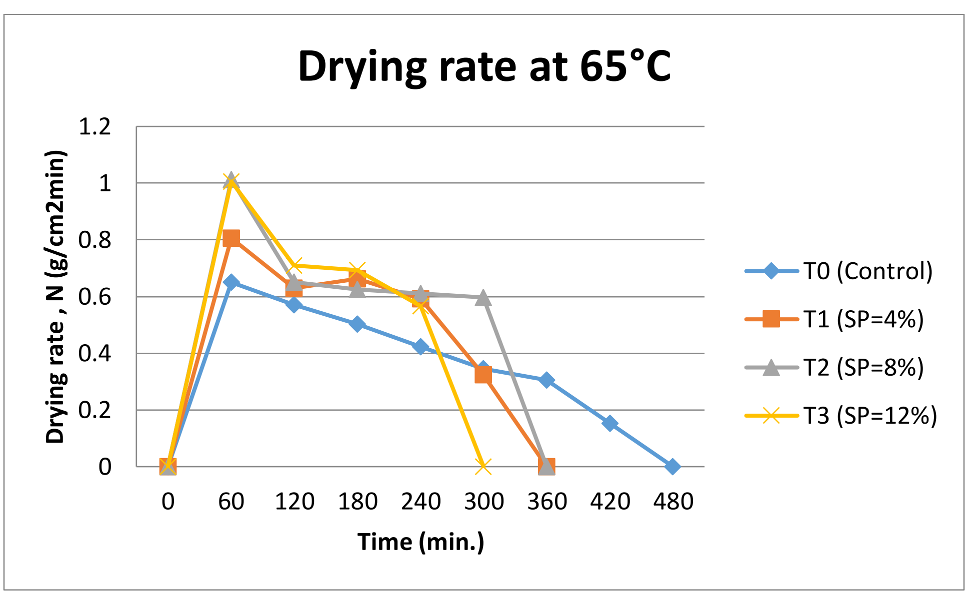

Figure 15. Effect of soy protein concentration level on drying rate of foam mat dried onion paste at 65°C

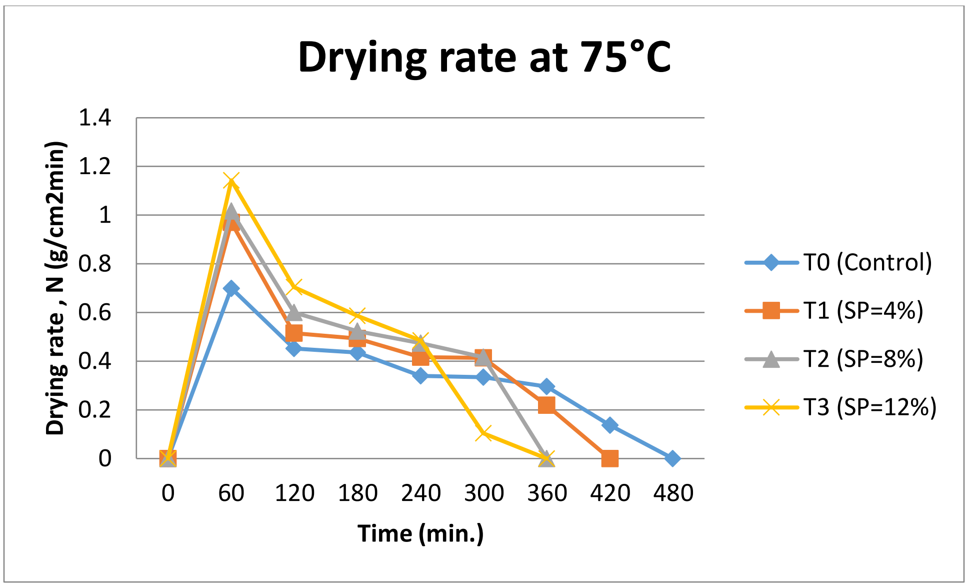

Figure 16. Effect of soy protein concentration level on drying rate of foam mat dried onion paste at 75°C.

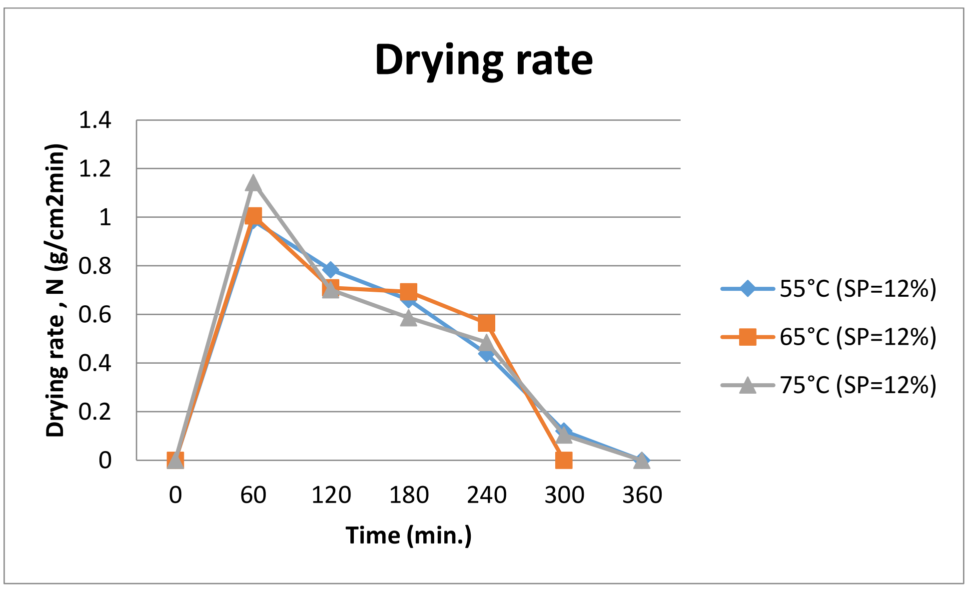

Figure 17. Effect of different temperatures (55°C, 65°C and 75°C) on drying rate of onion powders developed by 12% soy protein as foaming agent.

3.2. TSS (Brix %) of onion powders

TSS of fresh onion paste was 12 % while TSS of reconstituted foam mat dried onion powder was ranged from 11.666± 1.155 to 4.800± 0.200 which can be seen from table, 8. TSS of onion powder has significantly decreasing trend with increase in concentration of foaming agent. Analysis of variance (ANOVA) showed that only foaming agent have significant ($P<0.05$) effect onion total soluble solids of onion powder, while temperature effect was non-significant ($P>0.05$. As the soy protein concentration increased from (T_1) 4% to (T_3)12 % TSS of onion powder was decreased from 7.753± 1.946 to 5.333± 0.757at 65°C. Our results were in compliance with Rajkumar, *et al*. (2007). Many researchers have reported that this decline in TSS could be due to some heat sensitive compounds in food materials but use of these foaming agent has reduced the drying time and minimized the quality losses due to temperature effects. Only foaming agent concentration showed significant effects on TSS of onion powder while effect of temperature was non-significant.

Table 7. Mean drying rate of onion powder dried at different temperatures (55°C, 65°C and 75°C) using different concentration of soy protein as foaming agent

		Mean drying rate			
Sr. No	**Temperature**	**T_0 (Control)**	**T_1 (SP=4%)**	**T_2 (SP=8%)**	**T_3 (SP=12%)**
1	55°C	0.291± 0.109	0.371± 0.273	0.506± 0.273	0.598± 0.273
2	65°C	0.422± 0.169	0.603± 0.169	0.699± 0.169	0.744± 0.169
3	75°C	0.385±0.174	0.512± 0.174	0.606± 0.174	0.604± 0.174

Table 8. Effect of different concentration of egg albumin as foaming agent and drying temperatures on moisture content and total soluble solids (Brix %) of onion powder

Temperature	Moisture content				Total soluble solids (Brix %) TSS			
	T_0	T_1	T_2	T_3	T_0	T_1	T_2	T_3
55°C	28.636± 0.474	19.423± 0.425	14.347± 0.538	6.396± 0.176	11.666± 1.155	8.220± 1.680	8.100± 0.361	4.800± 0.200
65°C	8.410± 0.370	7.967± 0.266	7.216± 0.300	4.593± 0.102	9.966± 1.761	7.753± 1.946	8.133± 0.321	5.333± 0.757
75°C	8.183± 0.318	6.693± 0.331	5.646± 0.593	4.593± 0.102	10.667± 1.528	8.253± 1.675	7.833± 0.764	5.300± 0.650

Table 9. Effect of different concentration of egg albumin as foaming agent and drying temperatures on water solubility index (WSI) and water absorption index (WAI) of onion powder

Temperature	Water solubility index (WSI)				Water absorption index (WAI)			
	T0	T1	T2	T3	T0	T_1	$T2_2$	T_3
55°C	20.330± 1.527	10.830± 2.254	27.330± 2.517	14.500± 0.500	2.683± 0.025	1.790± 0.010	1.690± 0.017	1.307± 0.023
65°C	9.500± 1.500	19.667± 1.547	29.333± 2.082	30.833± 1.607	2.543± 0.012	1.786± 0.006	1.570± 0.017	1.183± 0.023
75°C	29.333± 1.528	60.167± 1.258	54.667± 0.577	73.833± 2.466	2.490± 0.051	1.576± 0.015	1.493± 0.015	1.093± 0.080

3.3. Water solubility and absorption index

Water solubility index is the property of powders to show their ability of being homogenously mixed with water. Excellent powder is that which easily and instantly wet and submerged rather than float or diffuse without swelling. Analysis of variance (ANOVA) showed that temperature have highly significant ($p<0.01$) effect on water solubility index of onion powder while effect of foaming agents was non-significant ($p>0.05$) for water solubility index of onion powder. The effect of different concentration levels of soy protein on onion powder is given in table 9. From results it was found that with increase in concentration of soy protein resulted in increase in solubility of onion powder. It is because with increase in concentration of foaming agent structural stability of foams raised, which increased the porosity of onion powders. Hence, with increase in stability of foams in drying process, more number of bubbles will remain during whole drying process and these bubbles will rise porosity and ultimately solubility of powders will increase. Moreover, lower moisture content in foamed onion powders resulted in less sticky nature of powder with high surface area which increase water binding capacity of these powders. From the data which is given in table, 9, it was found that 9.500± 1.500 was WSI of un-foamed T_0 (Control) treatment, while 30.833± 1.607 was the value of WSI of the onion powder which was treated with soy protein (T_3)12% concentration dried at 65°C. Increase in temperature from 55°C to 75°C solubility of onion powder was significantly increased. It is because at 55°C the drying rate is very low as compare to drying at 65°C and 75°C. At 55°C bubbles have to stand for more time during entire drying process, while with increase in temperature drying taken place a short time so bubbles have less time to get collapsed. Therefore, at higher temperature reduction in drying time decreased the bubble collapse. As bubbles increases the porosity by which solubility of onion powders increased at higher temperature (Abbasi, *et al.*, 2016; Goula and Adamopoulos (2005). Maximum values for WSI was 73.833± 2.466 with (T_3)12% concentration of soy protein as foaming agent at 75°C.

Water absorption index is related to capacity of powders to absorb water; it is also known as hydration capacity. Several other properties of powders like moisture content, TSS, porosity and texture of powders will be altered due to increase in water absorption index. Moreover, all microbes are water loving so increase in WAI results into microbial attack and loss of quality attributes. Analysis of variance (ANOVA) showed highly significant ($p<0.01$) effect of foaming agent and temperature on water absorption index of onion powder. As temperature increased from 55°C to 75°C water absorption index was significantly decreased from 2.683± 0.025 to 2.490± 0.051 for (T_0) control, 1.307± 0.023 to 1.093± 0.080 soy protein (T_3)12% used as foaming agent. Maximum and minimum values of water absorption index was 2.683± 0.025 at 55°C T_0(Control) and 1.093± 0.080 at 75°C Soy protein (T_3)12% as foaming agent was used which can be seen in table, 9. This decrease in water absorption index due to increase in temperature is because of denaturation of protein molecules. Similarly, Wilson, *et al.* (2012) reported that with increase in temperature from 65°C to 85°C results into significant decrease in WAI. Azizpour, *et al.* (2016) reported, with increase in temperature from 45°C to 90°C WAI decreased significantly. In another study, Franco, *et al*. (2015) also reported similarly that with increase in temperature from 50°C to 70°C WAI decreased.

4. Conclusions

Onion powder was prepared by foam-mat drying technique using soy protein in different concentration as foaming agent. Effect of foaming agent and different drying temperature was studied on moisture loss and drying rate of onion paste. From the results it was found that onion paste which was treated with different concentration of soy protein as foaming agent was dried in short time as compare to un-foamed onion paste. Moisture loss from foamed onion paste was higher because with foaming treatment surface area for drying was increased which resulted into faster and easy removal of moisture of foamed onion pastes. Moreover, drying rate of onion pastes which were treated with different concentration of soy protein was higher as compare to un-foamed onion pastes.

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