



Effect of Dehydration Techniques on Nutritional Quality, Functional Property, and Sensory Acceptability of Dried Onion Powder

APARNA¹, GARIMA GUTAM¹, ANIL KUMAR CHAUHAN^{1*},
MEENAKSHI SINGH² AND ARSHYA SINGH¹

¹Department of Dairy Science and Food Technology, Institute of Agricultural Science,
Banaras Hindu University, Varanasi, India

²Technology Management Directorate (Socio-economic Ministry Interface)
Council of Scientific Research, New Delhi, India

*Corresponding author E-mail: anilchauhanfst@gmail.com

Abstract: Onion is one of the most important vegetables used not only for food flavoring but also has many medicinal benefits like wound healing, antimicrobial, and anti-inflammatory properties because it comprises many bioactive, antioxidant and phenolic but its preservation is challenge for food researchers. So to prevent price hikes and increase the shelf life of onion, preservation is very important step. The present study was conducted to evaluate the effect of the sun, tray, vacuum, and freeze-drying treatment on the nutritional, functional, and sensory properties of onion powders. Nutritional, color, texture, rheological, and rehydration ratio of freeze-dried onion powder were better than other drying processes. Volatile compounds retain in lyophilized onion powder, however, may be readily lost during other drying processes. Based on the microstructure analysis of onion powder, the freeze-dried powder was found intact and porous cell. There was no leak of solute concentration. So, it can be concluded that among all drying the methods, freeze-drying is considered best method to preserve onions and was well accepted by the panel.

Keyword: onion, drying, phytonutrient, pungency, SEM

Received : 8 January 2021

Revised : 19 January 2021

Accepted : 8 February 2021

Published : 30 June 2021

TO CITE THIS ARTICLE:

Aparna, Garima Gutam, Anil Kumar Chauhan, Meenakshi Singh & Arshya Singh. 2021. Effect of Dehydration Techniques on Nutritional Quality, Functional Property, and Sensory Acceptability of Dried Onion Powder *Journal of Food and Agriculture Research*, 1: 1, pp. 30-46

1. Introduction

Onion (*Allium cepa* L.) crop has great economic importance and used in daily cuisine all over the world. India is the 2nd largest onion producer country in

the world. Onions that are found in India are famous due to their pungency and availability round the year. It is usually consumed as a fresh, essential oil or in powder form in commercial food products. It is an extraordinarily nutritious vegetable that is recognized for its functional compound and high level of antioxidant activity connected to its ascorbic acid, anthocyanins, flavonoids (quercetin and its conjugates) content (Tedesco *et al.* 2015). Onion flavonoids have dual action; the first one is helping in radical scavenging activities, and the second is acts as an agent of mechanisms causative to prevent carcinogenesis (Griffiths *et al.* 2002). Onion consisting of quercetin and its glycosylated derivatives play a significant role in chemopreventive actions. Thiosulfinates (TSs) and α -sulphinyl disulfides (cepaenes) were principal active constituents exhibiting anti-asthmatic activity (Ko *et al.* 2015). In last two decades consumption of onion has highly increased because of its well-established health advantages like reducing cardiovascular disease, exhibiting hypolipidemic activity due to the presence of S-methyl-L-cysteine sulphoxide and its protein, saponins, and phenolic compounds has antibacterial and antifungal capabilities (Insani *et al.* 2016). Its oils, juice, and aqueous extracts were effective against gram (+) bacteria, many yeast species, and dermatophytic fungi associated with dental problems (Kumari *et al.* 1995). But the problems are that onion (*Allium cepa*) bulbs are perishable in nature and short shelf life. They undergo sprouting, more susceptibility to postharvest microorganisms, and are readily softened because of inherent enzymes, such as pectin methylesterase and polygalacturonase (Coolong *et al.* 2008). All these factors contribute 20–40% post-harvest loss of onion during storage in India (NABARD, 2016).

Drying fresh onion to flakes, powder, chip or mince is one of the common and most effective processes to increase shelf life of onion (Ahvenainen, 1996). According to FAO (2017), the global market of dehydrated onion products in 2017 was about US\$ 950 Mn, which is likely to reach in excess of US\$ 1,500 Mn by the end of 2028. China is the second-largest producer of dehydrated onion, contributing 22.1% of the gross world production. Dehydrated onion is commonly used as an ingredient or as a flavor additive in a several of food products, including snacks, soups, frozen foods, sauces, retorted products, meat products, salad dressings, pickles, pickle relishes (Arslan and Özcan, 2010). So, the demand for best quality dehydrated onion is increasing and significant commercial value because of its culinary and medicinal properties in “Nutraceuticals.”

To increase the shelf life of onion, various drying methods used such as sun, tray, vacuum, spray, and freeze-drying that affects onion quality such

as the surface structure (morphology, particle size, porosity, and densities), hydrophilicity/hydrophobicity, sinking, swelling, dispersion, solubilization or dissolution, disintegration, wetting and rehydration ratio (Fitzpatrick *et al.* 2016). Drying techniques contain a series of different processing phases affecting final quality of the product. In Onion drying, major quality problems are the loss of characteristic color and flavor. The volatile compounds have low boiling points which are responsible for aroma and flavor in onion are lost during drying at high-temperature (Adam *et al.*, 2000). Drying also causes undesirable browning reactions that are responsible for decreasing nutrient value, degrade color, and flavor (Seifu *et al.*, 2018). In the previous years, numerous quality guidelines for the dehydrated onion have been developed an example of these is ADOGA (American Dehydrated Onion and Garlic Association). Keeping the mind that the drying affects nutritional, physicochemical, and quality attributes of onion, the present study was carried out to investigate the best drying techniques that retail maximum nutritional and quality attributes of onion without affecting organoleptic properties.

2. Materials and Methods

2.1. Materials

For the conducted study, freshly harvested onion (cultivar Bhima Super), a commercially available variety, is selected and purchased from the local market. The onion was kept in the dark at 5-8°C until used. All the required chemicals used were of analytical grade.

2.2. Methods

2.2.1. Drying

Four different dryer (Tray, Vacuum, Freeze dryer) were used which present laboratory in Department of Dairy Science and Food Technology, Institute for Agricultural Sciences, Banaras Hindu University, Varanasi. The dryer contains of heating, airflow and humidifier control section.

2.2.2. Production of Dried Onion Powders (DOP)

Onion bulbs were manually peeled, cleaned with water, and sliced using an electrical slicer with adjustable blades (Bajaj multifunctional cutter), which were dried in a different type of dryers such as sun, tray, vacuum oven, and freeze dryer.

2.2.2.1. *Sun dry*: Sun-drying was carried out in single layer stainless steel trays and covered with a mosquito netting material to prevent flies during drying. The trays were then kept on a 1.5m high stand in the sun with an average temperature of 45 ± 5 °C with 22–24% of relative humidity. The sliced onion was exposed to the sun from 9 a.m.-4 p.m. To prevent rehydration during night, the onion slices were packed in PE pouches and kept in a desiccator (Fig 1.a).

2.2.2.2. *Tray and Vacuum dryer*: One thousand grams of the sliced onion were evenly spread on a stainless-steel tray (32 cm × 23 cm × 3 cm) and dried at 55 ± 50 °C in tray and vacuum drier (Fig 1.b& c). We performed the experiments at this temperature because, in a previous study, the best range of temperature for drying fruits and vegetables is between 55 to 75°C (Olusola, 2009).

2.2.2.3. *Freeze dryer*: Before freeze drying, onion slices are frozen in deep freezer at -20 °C. Then frozen samples were dry in freeze-dryer (Narang Scientific Works PVT.LTD, New Delhi) at 6.2 Pa of vacuum pressure at -40 °C for 48 h (Fig 1.d)

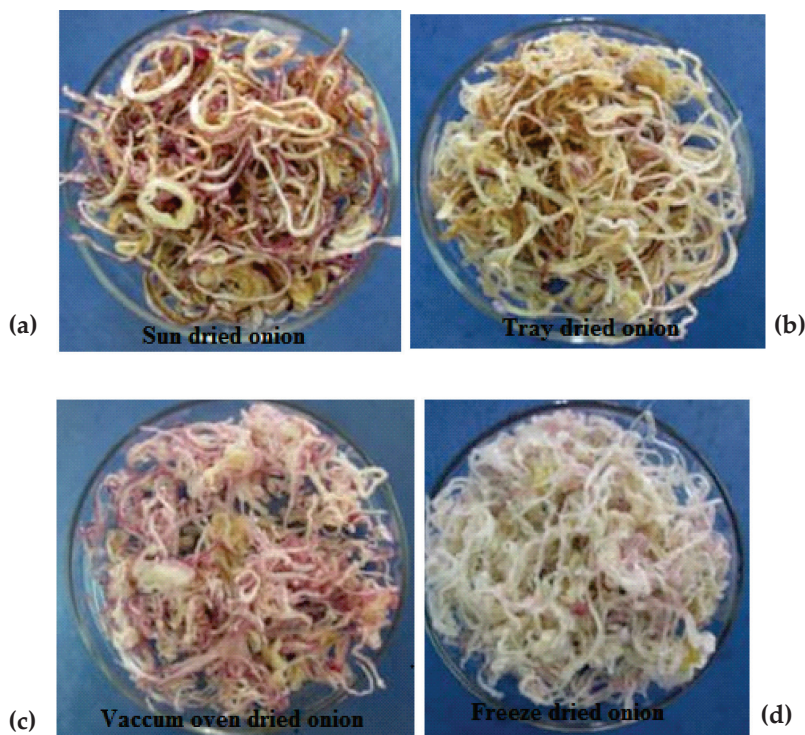


Figure 1: Dried onion slices a- sun dried onion b- tray dried onion, c-vacuum dried onion d-freeze drying onion

Drying times of 24–48 h were required to reach a moisture content of 12–15%. Dried onion slices were finely ground into powders with a high-speed mixer (Maharaja Grinder), packed in HDPE pouches and stored in the refrigerator until analysis.

2.2.3. Determination of Nutritional Composition and Trace Elements

A moisture analyzer was used to analyze moisture, which works on halogen heating technology. The protein content was estimated with Kjeldahl nitrogen analyzer (Kel Plus –DISIYL EMS), fat content with SOCS-PLUS model SCS8, Fibertec™ 1023 - semi-automatic crude fibre analyzer is used to determine crude fibre. All proximate composition of dried onion sample was analyzed according to AOAC (2012) method. The Lane–Eynon volumetric method was used to determination of total sugar.

Macro and microelements like calcium (Ca), iron (Fe), copper (Cu) and potassium (K) were detected by using AAS (Atomic Absorption Spectrophotometer) (Perkin Elmer) according to the method explained by Aparna *et al.* (2018).

2.2.4. Physio Chemical Analysis

2.2.4.1. *TSS, pH and titratable acidity*: Total soluble solid, pH, titratable acidity of DOP was carried out by the methods described Ranganna, 2001. TSS of BFMS was determined by hand refractometer at 20°C. Titratable acidity determined by titration against 0.1N NaOH soluble using few drops of phenolphthalein indicator and Cyber scan 510 pH meter was used determination of pH.

2.2.4.2. *Color*: The color of food product influences consumer acceptability. The surface color values of dried onion powder (DOP) in the CIE $L^*a^*b^*$ was measured using Color Flex, Hunter Lab. Result was comes in terms of L^* (0: Black, 100: White), a^* (-a: Greenness, +a: Redness) and b^* (-b: Blueness, +b: Yellowness).

2.2.4.3. *Texture profile of dried onion slices*: The texture of the dries onion slices was determined by using a TA.XT plus texture analyzer with a compression plate was used to compress dried onion slices. The hardness and chewiness of dehydrated onion slices were recorded.

2.2.4.4. *Water activity*: Water activity (a_w) of the dried onion powder samples was determined by water activity meter (AquaLab, model 4TE, Decagon Devices Inc., Pulluman, WA, USA) with 25°C temperature.

2.2.4.5. *Wettability*: Wettability of dried onion powder was determined by the procedure used by Fitzpatrick *et al.* (2016) with slight modifications. 0.1 g

of powder sample was spread over the surface of 100ml deionized water at room temperature without stirring. The time was noted until the last particle of powder submerged.

2.2.4.6. *Bulk density*: Bulk density was estimated as the method explained by Seifu *et al.* (2018). Twenty grams of dried onion powder was taken into a measuring cylinder (100 ml), and the volume, including the contribution of the interparticulate void volume was noted.

$$\text{Bulk Density} = (\text{Mass of untapped BFMS}) / (\text{Volume of BFMS})$$

2.2.4.7. *Rehydration ratio*: The rehydration properties of the dried onion slices were calculated in terms of the rehydration ratio. Rehydration ratio of dried onion slices were determined by the methods suggested by Ranganna S. (2001), in which sample weight before and after rehydration was calculated.

2.2.5. Analysis of Nutraceuticals for SDOP, TDOP, VODOP & FDOP

2.2.5.1. *Phenolic and Flavonoids content*: Total phenolic and flavonoid content in dried onion powder was estimated by the procedure described by Tyagi *et al.* (2020).

Phenolic and flavonoid compounds from DOP was extracted with CH₃OH/H₂O/HCOOH in ratio of 70: 29.7: 0.3 v/v/v. Total phenolic content of BFMS extract was estimated by using the Folin's phenol reagent and standard curve was prepared by gallic acid. Results were expressed in mg/100g.

Aluminum chloride solution was used to evaluate TFC in which rutin trihydrate (RT) was used in preparation of standard curve and result mg/100g expressed in µg RT equivalent /ml of extract.

2.2.5.2. *L-Ascorbic acid*: L-Ascorbic acid was determined by the method suggested by Srivastava and Kumar (2003), in which the sample was prepared in meta-phosphoric acid (15%) and titrate against 2,6 dichlorophenol- indophenol using phenolphthalein as indicator to a pink endpoint.

2.2.6. Determination of Flavor

Pyruvic acid concentration is indicator of the flavor and aroma strength of onions, was expressed in mmol/g with a spectrophotometric method (Seifu *et al.*, 2018).

2.2.7. Sensory Evaluation

After rehydrating onion powder at 2:1 ratio water: powders v/v for 1 hour, sensory analysis of the samples was done. Fifteen semi-trained judges at Banaras Hindu University, Varanasi, carried out the sensory analysis. The

sensory evaluation was planned in properly illuminated lights, humid free & ventilated room by maintaining hygienic condition. According to Seifu (2018), the sensory analysis was done where sensory attributes, i.e., color and appearance, aroma, taste, and overall acceptability. The sensory properties were presented on a 5-point scale, 5 : extremely desired quality, 4 : desirable quality, 3 : tolerable quality, 2 : dislike, and 1 : defective product.

2.5. Powder Morphology

The powdered samples' appearance and shape were observed by placing the powders on aluminum stubs using a double-sided adhesive tape and were investigated by scanning electron microscopy (SEM) utilizing model Quanta 200 camera (Thermo Fisher Scientific, USA) with an acceleration of 20kV voltage.

2.6. Statistical Analysis

All the experiments were carried out in triplicate, and the results were expressed as mean \pm SD (standard deviation). Statistical analysis was performed by applying ANOVA using MINITAB 17 software.

3. Results and Discussion

3.1. Nutrient Composition and Trace Elements of SDOP, TDOP, VODOP and FDOP

The nutritional analysis results of sun, tray, vacuum and freeze-dried onion powder are depicted in Table 1. The moisture content of dried onion powders i.e., sun, tray, vacuum oven, and freeze-drying, was 12.94, 12.70, 12.68, 12.46 percent, respectively, after 48 h drying. Non-significant difference ($P < 0.05$) was observed in onion powders' moisture content dried by various methods. Protein, fat, crude fiber, and ash contents of sun, tray, vacuum oven, and freeze-dried onion powder varied from 8.49 to 8.95, 0.81 to 0.97, 4.21 to 4.66, and 3.28 to 3.93 percent, respectively. Minerals are essential for the maintenance of human health. Calcium, iron, copper, and potassium content of onion powder dried in the sun, tray, vacuum oven, and freeze-dried was ranged from 332 to 341, 1.50 to 1.58, 0.70 to 0.83 mg/100g, respectively (Table 1). The above results show that different drying methods do not influence protein, fat, crude fiber, ash, and mineral. These results reasonably coincide with Sangwan *et al.* (2010) and found similar protein, fat, mineral, and crude fiber content of onion powder dried by four different drying methods viz., shade, oven, solar, and microwave.

Table 1: Nutritional and essential metal composition of SDOP, TDOP, VODOP and FDOP

Parameter	SDOP	TDOP	VODOP	FDOP
Moisture (%)	12.94 ± 0.21a	12.70 ± 0.11	12.68 ± 0.14	12.46 ± 0.11
Protein (%)	8.66 ± 0.10	8.58 ± 0.13	8.49 ± 0.11	8.95 ± 0.18
Fat (%)	0.84 ± 0.03	0.81 ± 0.06	0.86 ± 0.02	0.97 ± 0.05
Ash (%)	3.44 ± 0.38	3.40 ± 0.35	3.28 ± 0.23	3.93 ± 0.27
Crude fibre (%)	4.21 ± 0.31	4.32 ± 0.22	4.60 ± 0.06	4.66 ± 0.12
Total sugar (%)	15.72 ± 0.82	19.18 ± 1.42	22.35 ± 0.47	26.68 ± 0.88
Calcium (mg/100g)	332 ± 1.14	335 ± 1.21	336 ± 1.41	341 ± 1.11
Iron (mg/100g)	1.50 ± 0.04	1.55 ± 0.09	1.53 ± 0.02	1.58 ± 0.08
Copper (mg/100g)	0.70 ± 0.08	0.78 ± 0.02	0.83 ± 0.08	0.81 ± 0.09
Potassium (mg/100g)	220.83 ± 4.66	223.04 ± 3.66	226.5 ± 3.60	227.21 ± 5.26

Values are Mean ± Standard deviation (SD) of triplicates

Significant correlations were found to depict the impact of drying conditions on the total sugar content of onion dried powder, as demonstrated in Table 1. Change the drying condition from freeze to sun drying resulted in 26.68 to 15.72% losses of total sugar. The sugars degrade by Maillard and browning reactions formed by the reaction between sugars, amino acids, and protein. This result proposes that to maintain onion powder's sweetness during the drying, sun drying should be avoided.

3.2. Color and Texture Analysis of Onion Powder

Drying exerts an articulated impact on the color of onion powder. The change of color could be attributed to the maillard browning reactions during the drying process. It was observed that different drying techniques significantly influence the color parameter (L^* , a^* and b^*), as shown in Table 2. L^* parameter decreased significantly during sun, tray, and vacuum drying for onion powder. Although the highest value of L^* was obtained for freeze-dried onion dried powder (80.09). The mean score for a^* value, which indicates the redness of onion powder was varied from 5.47, 2.46, 1.51 and 0.72 in sun, tray, vacuum and freeze drying respectively. Lowest a^* value in freeze dried sample which is almost similar to fresh onion. The chroma parameter b behaved similarly to a^* parameter during the drying process. Value of b^* parameter obtained from different drying methods were positive (28.57 for sundried; 26.41 for tray dried; 23.48 for vacuum dried; 19.88 for freeze-dried). The b value increased most for the sun-dried sample.

The results indicated that the drying type had a significantly affected the values of L^*a^* and b^* . The browning of vegetables and fruits during drying is due to both enzymatic and non-enzymatic browning reactions (Edith *et*

*al.*2018). Therefore, it can be concluded that in a freeze drier and vacuum drier, prevented enzymatic browning reaction and no burning occurred, resulting in the stability of L^* , a^* and b^* values, whereas in the other methods, occurrence of millard reaction and burning.

Sun, tray, vacuum, and freeze dried 6 mm thick onion slices were used to determine hardness and chewiness in the texture analyzer. Hardness and chewiness are proportionally correlated with others, i.e. Hardness increases the chewiness of the sample. Textural properties of dried onion slices are presented in Table 2. The hardness and chewiness of dried onion slices increased from freeze dry to sundry. Hardness increase because on drying of the onion tissue's porous structure got damaged, and disintegration of cell wall material reduces the sample's turgidity and resulted in an increase in the tissue's hardness. A similar result of hardness and chewiness in vacuum dried onion powder has been reported by Mitra *et al.* (2015).

3.3. Physico-chemical Analysis of DOP

3.3.1. TSS, pH and Titratable Acidity

Drying techniques has significant effect on TSS, pH, and titratable acidity as shown in Table 3. The total soluble solid of fresh onions was 5.27°Brix, which is significantly lower than that of dried product. There were no significant TSS value changes among the four drying techniques (sun, tray, vacuum, and freeze-drying) because the moisture content of onion powder of different drying conditions is almost same. Tray-dried onion powder has showed the highest total soluble solid content (6.41°Brix), but there was no significant difference among the other three drying conditions. TSS changes were also reported by Seifu *et al.* (2018) on drying various onions variety at different temperature levels.

The pH values of fresh onion, sun, tray, vacuum, and freeze-dried onion powder were 5.36, 3.79, 4.05, 4.16, and 4.31, respectively. Although fresh pH values were different from dried onion powder, the pH values decreased when shifting from freeze to sun drying and reached 4.31 to 3.79. A decrease in pH level might be related with the accumulation of more organic acids with moisture removal at different drying conditions. However, all drying techniques have pH less than 4.5, which control the growth of food pathogenic microorganisms except yeasts and molds, but reducing a_w value, they can be controlled. This study's results agree with Ozgur *et al.* (2011), who reported that decrease in pH value after drying.

Table 2: Color value and texture measurement of TC, CC, and TCC

Parameter	SDOP	TDOP	VODOP	FDOP
L*	59.47±0.18	76.68±0.11	82.69±0.22	87.97±0.14
a*	5.47 ±0.02	2.46±0.05	1.51±0.02	0.72±0.03
b*	28.57±0.36	26.41±0.21	23.48±0.31	19.88±0.28
Texture				
Hardness(N)	85.90±0.52	77.45±0.41	76.94±0.80	73.40±0.63
Chewiness	81.23±0.19	72.48±0.12	68.13±0.15	62.57±0.17

Table 3: Quality parameters of SDOP, TDOP, VODOP and FDOP

Parameter	Fresh onion	SDOP	TDOP	VODOP	FDOP
TSS(reconstituted)	5.27±0.38	6.30±0.29	6.41±0.17	6.27±0.26	6.21±0.28
pH (reconstituted)	5.36±0.17	3.79±0.12	4.05±0.19	4.16±0.10	4.32±0.11
Titrateable acidity (%)	0.287±0.02	0.390±0.06	0.345±0.03	0.327±0.06	0.313±0.05
Water activity	0.964±0.005	0.292±0.004	0.277±0.002	0.270±0.006	0.266±0.001
Wettability	-	42sec	39sec	36sec	30sec
Bulk density (g/cm ³)	-	0.892 ±0.14	0.878±0.17	0.815±0.21	0.789±0.11
Rehydration ratio	8.51±0.63	5.65±0.86	6.86±0.70	7.25±0.82	7.97±0.59

Titrateable acidity and pH were correlated with each other as pH decrease TA increase proportionally. TA of sun dried onion powders giving the highest (0.390%) and freeze-drying giving the lowest (0.313%) TA. These results signified that increases in acidity value as drying conditions change, which may be due to sugar in onion converted into organic acids. Ozgur *et al.* (2011) also found that after drying TA value of onion increases.

3.3.2. Water Activity

Water activity (a_w) plays a significant role in the growth of microorganisms cause spoilage of food and loss of functional properties of food due to the mobility of molecule. Safety and mechanical point of view a_w values are also important. From a mechanical point of view, if water activity in the range of 0.35-0.50, unacceptable organoleptic changes could be produced. From a safety viewpoint, a_w values below 0.6 can be considered chemically and microbiologically stable because free water available for biochemical reactions is low (Correia *et al.* 2017). From Table 3, water activity (a_w) of onion powders by different drying conditions was between 0.292-0.266, which can be considered stable from microbial spoilage.

3.3.4. Bulk Density

Untapped density is a significant parameter for the powder because it indicates the area cover by the powder, which is vital for packing industry. Bulk density results of onion powder are presented in Table 3. Drying at high temperature makes sample denser so required stronger packaging material. Moreover, lower bulk density powder is preferred because it improves dispensability when reconstituted in water (Udensi & Okoronkwo, 2006).

The researchers reported that the remaining solids after removal of moisture have higher densities than water, and the overall solid density increases as moisture are removed. The bulk density values decrease from 0.892 to 0.789, with the shift from the sun to freeze drying. This study's results are in line with those reported for tomato (Goula and Adamopoulos, 2005).

3.4. Rehydration Characteristic of Dried Onion Slices

The rehydration characteristics are widely used as indicators of the quality of the dried product. Rehydration is a complex process influenced by chemical and physical changes associated with drying techniques and temperature during dehydration. The rehydration ratio of onion slices ranges from 7.97 to 5.65 along with the drying methods (Table 3). Each drying method had significantly affected the rehydration ratio of dried onion slices. It was found that the rehydration ratio was more in the case of freeze dried samples that represent rehydration efficiency of freezer dried onion slices was more than other treated onion slices. Variation in rehydration ratio might be due to the drying process increases ruptured and shrunken cells that cause solute migration and loss of osmotic pressure, and changes in the cell walls' permeability. The result found in the experiment was nearly similar to the one reported previously with drying, and the treatments preceding dehydration and reported rehydration ration of onion were 6.87 (Lewicki *et al.* 1998).

3.5. Phytochemical Characteristics of SDOP, TDOP, VODOP, and FDOP

3.5.1. Total Phenolic

Phenols are essential plant constituents. Various researches have confirmed that phenolic and flavonoid compounds are the most prominent antioxidative constituents in vegetables, fruits, and cereals (Choi *et al.* 2007). The major phenolics and flavonoid found in onion are gallic acid, ferulic acid, quercetin,

and their glycosides. These constituents have a proportional relationship with total antioxidant activity. Polyphenol and flavonoid content of sun, tray, vacuum oven and freeze dried onion powder was presented in Table-4. Significant differences were observed in total polyphenol and flavonoid content of onion among drying methods. This result might be due to thin cell of onion powder came in contact with temperature and hot air. So atoms of O₂ from the atmosphere react with hydrogen atoms from the OH group to form quinone and H₂O₂ (Mba *et al.* 2019). Similar effect of drying method on polyphenol content of onion was reported by Edith *et al.* (2018).

3.5.2. Ascorbic Acid Degradation

Vitamin C content is considered a nutritive parameter of processed food because it has low stability during food processing, especially for heat treatment. Ascorbic acid is known to be temperature dependent. In the fresh onion, the vitamin C content was 36.11 mg/100 g solid. It was found that the magnitude of vitamin C was significantly affected by the drying techniques shown in Table 4. The ascorbic acid contents decrease from 15.36 mg/100 g DM (FDOP) to 4.98 mg/100 g FM (SDOP). A significant decrease of ascorbic acid content was observed in the sun and tray drying type, which was 13.79% and 16.86% respectively of fresh onion. The adverse effect of temperature on ascorbic content of onion powder was also reported by Seifu *et al.* (2018). Freeze-dried onion powder has the highest ascorbic acid content because in freeze-drier ice sublimize directly to vapor at low temperature and pressure. Vitamin C losses may be due to several factors, i.e. thermosensitive and photooxidative reactions.

3.6. Pyruvic Acid

A trustworthy indicator of pungency is pyruvic acid. Pungency in dried onion depends upon the condition and temperature used during drying because

Table 4: Ascorbic acid, total phenolic and flavonoid content of SDOP, TDOP, VODOP and FDOP

Items	TPC (mg of gallic acid eq/100 g)	TFC (mg of quercetin eq/100 g)	Ascorbic acid (mg/100g)	Pyruvic acid (μmol/g)
Fresh	36.11±0.59	82.61±1.09	229.17±1.12	82.56±0.79
SDOP	4.98±0.12	20.53±0.072	148.36±0.98	73.66±0.64
TDOP	6.09±0.33	23.06±0.44	155.56±1.10	74.51±0.70
VODOP	11.55±0.41	27.01±0.56	163.19±0.91	77.97±0.51
FDOP	15.36±0.16	31.77±0.84	185.45±0.33	79.33±0.48

pyruvic acid molecules break at high temperatures. The pyruvic acid content in onion also depends on several factors such as cultivars, sugar content, dry matter, sulphur nutrition, and maturity. Pyruvic acid is an unwavering product from the hydrolysis of S-Alk(en)yl-L-cysteine sulfoxide. When a cell of the onion is destroyed or ruptured by chopping and cutting, the enzyme alliinase hydrolyzes S-alk(en)yl-L-cysteine sulfoxide and releases (Adam *et al.* 2000). Pyruvic acid content for fresh, sun-dried, tray dried, vacuum, and freeze-dried onion samples were found 82.56 $\mu\text{mol/g}$, 73.66 $\mu\text{mol/g}$, 74.51 $\mu\text{mol/g}$, 77.97 $\mu\text{mol/g}$, and 79.33 $\mu\text{mol/g}$, respectively. The pungency of onion slice reduces significantly at ($p < 0.05$) when drying condition changes (freeze to sun drying) because most volatile compounds have a low boiling point. In this study pyruvic acid concentration in fresh and freeze dried onion powder has no significant changes were observed.

3.7. Powder Morphology

SEM (Scanning Electron Microscopy) was used to study the morphology of the dried onion powder. This morphological characteristic significantly affects the flowability property of the powders. The micrographics of SDOP, TDOP, VODOP, and FDOP showed structural differences as shown in Figures 2(a-d). According to the images, continuous intact structure, amorphous and porous regions were destroyed during the shift from freeze to sun drying technique. Dried onion samples showed collapsed inter-cell connections and damaged tissue structures with the broken cell wall. In the comparative study between all four samples, it can be inferred that the lyophilized sample's morphology is almost similar to control powder because no collapse in tissue was found, and cell walls were found intact. A similar micrograph was also found by Mitra *et al.* (2015) that microstructure of osmotically treated vacuum dried onion was better than convective air drying.

3.8. Sensory Evaluation

A descriptive sensory evaluation (DSE) was conducted to analyse the effect of drying techniques on the sensory properties of the onion samples. Fig. 3 shows the data related to sensory evaluation. The sensory rating for colour and appearance, aroma, taste, and overall acceptability declined when drying condition changes from freeze to sun drying. At sun and tray drying, significant unacceptable changes are observed from fresh control sample in all sensory parameter. It means that onion slices in the sun and tray drying decreased the liking, this result may be due to loss of sulfur-containing volatile oil and

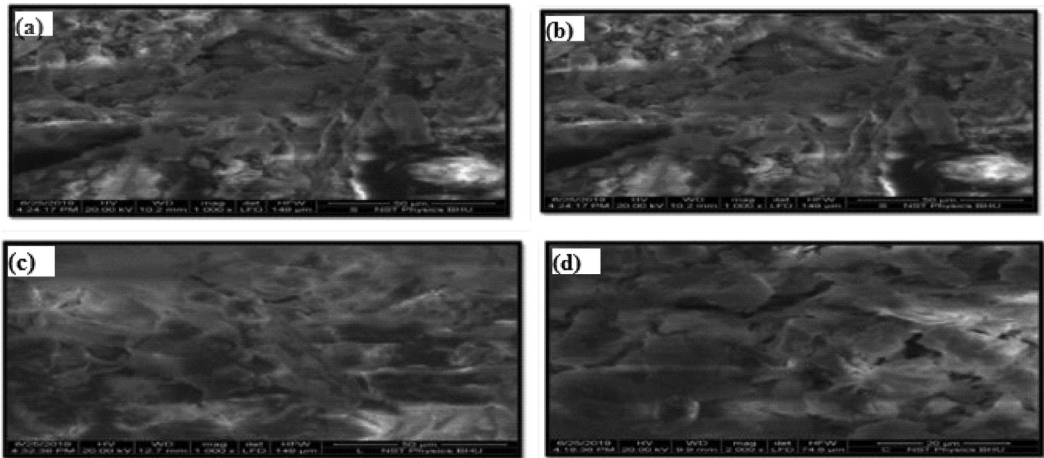


Figure 2: SEM micrographs of dried onion powder a- sun dried onion b- tray dried onion, c-vacuum dried onion d-freeze drying onion

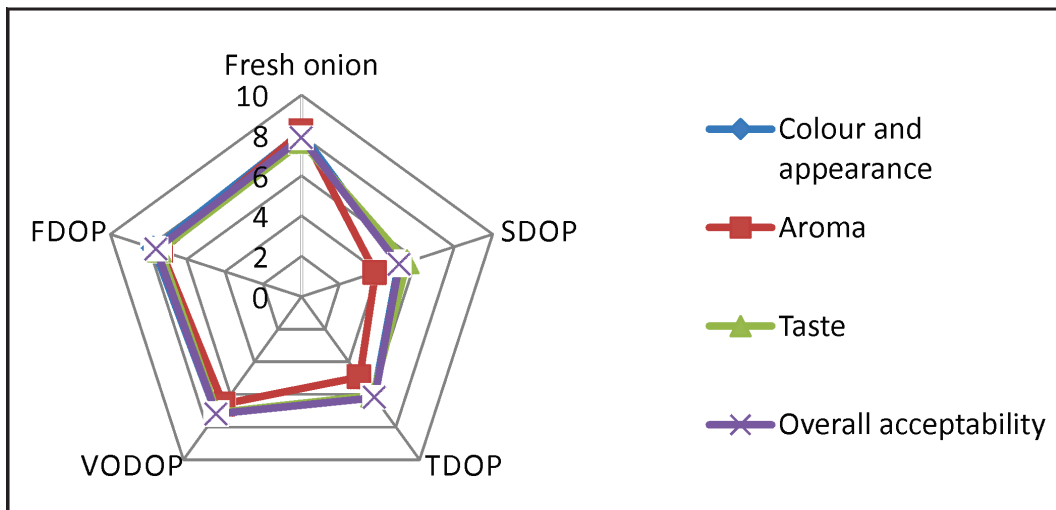


Figure 3: Descriptive sensory analysis of onion powders

non-enzymatic browning that occurred faster than other methods. In the case of all sensory parameter, freeze-dried onion very near to control samples. Hence, drying of onion slices in freeze-drying was acceptable without causing any adverse effect on the sensory attributes and considered optimum drying condition for onion.

4. Conclusions

It is concluded that freeze dried onion powder/flakes is nutritiously superior, highly acceptable among other dried onion powder and healthy without any

preservative. Freeze dried onion powder retains protein, fat, ash, and crude fibre content, whereas it has low moisture content and water activity which revealed that it has a longer shelf life with low wettability time and instantly soluble in water. Freeze dried onion powder is rich in phenolic, flavonoid, and ascorbic acid content, which is helpful in maintenance of the good health and treatment of many contagious diseases. Pyruvic acid content which denotes pungency and volatile compound present in onion showed that degradation in pyruvic content when shift from freeze to sun drying. SEM analysis of freeze onion powder shows porous and intact cell wall without leak of solute concentrate. This type of onion powder may increase food product market with bioactive goodness and be advantageous to consumers those are progressively searching out food with good taste that can be instantly prepared, easily consumable, and wholesome. Further research is needed to observe the effect of drying on volatile composition of onion, FTLR and HPTLC analysis to be done. Onion powder can be tried with different value-added food products.

Reference

- Adam E, Mühlbauer W, Esper A, Wolf W, & Spiess W. 2000. Quality changes of onion (*Allium cepa* L.) as affected by the drying process. *Food/Nahrung*, 44: 32-37.
- Ahvenainen R. 1996. New approaches in improving the shelf life of minimally processed fruit and vegetables. *Trends in Food Science & Technology*, 7:179–187.
- AOAC. 2012. Official method of analysis 19th Ed. Association of Official Analytical Chemists. Washington D.C., U.S.A.
- Aparna, Chauhan AK, & Singh PK. 2018. Estimation of toxic, trace and essential metals (Pb, cd, Fe, Zn, Mn, Cu, Mg, K) in fruit and vegetable product (jam, ketchup, pickles) by atomic absorption spectrophotometer. *The Pharma Innovation*, 7: 313-317.
- APEDA. 2020. APEDA production profile of onion, India. 2020.
- Arslan D, & Özcan MM. 2010. Study the effect of sun, oven and microwave drying on quality of onion slices. *LWT-Food Science and Technology*, 43:1121–1127.
- Choi Y, Jeong HS, & Lee J. 2007. Antioxidant activity of methanolic extracts from some grains consumed in Korea. *Food Chemistry*, 103: 130-138
- Coolong TW, Randle WM, & Wicker L. 2008. Structural and chemical differences in the cell wall regions in relation to scale firmness of three onion (*Allium cepa* L.) selections at harvest and during storage. *Journal of the Science of Food and Agriculture*, 88:1277–1286.
- Correia R, Grace MH, Esposito D, & Lila MA. 2017. Wild blueberry polyphenol-protein food ingredients produced by three drying methods: Comparative physico-chemical

- properties, phytochemical content, and stability during storage. *Food Chemistry*, 235: 76-85
- Edith DMJ, Dimitry MY, Richard NM, Armand AB, Léopold TN, & Nicolas NY. 2018. Effect of drying treatment on nutritional, functional and sensory properties of three varieties of onion powders. *Journal of Food Measurement and Characterization*, 12:2905-2915.
- Fitzpatrick JJ, Van Lauwe A, Coursol M, O'Brien A, Fitzpatrick KL, Ji J, & Miao S. 2016. Investigation of the rehydration behaviour of food powders by comparing the behaviour of twelve powders with different properties. *Powder Technology*, 297: 340-348.
- Goula AM, & Adamopoulos KG. 2005. Spray drying of tomato pulp in dehumidified air: II. The effect on powder properties. *Journal of Food Engineering*, 66: 35–42.
- Griffiths G, Trueman L, Crowther T, Thomas B, & Smith B. 2002. Onions a global benefit to health. *Phytotherapy Research*, 16:603–615.
- Insani ME, Cavagnaro PF, Salomon VM, Langman L, Sance M, Pazos AA, & Galmarini CR. 2016. Variation for health-enhancing compounds and traits in onion (*Allium cepa* L.) germplasm. *Food and Nutrition Science*, 7:577–591.
- Ko EY, Nile SH, Sharma K, Li GH, & Park SW. 2015. Effect of different exposed lights on quercetin and quercetin glucoside content in onion (*Allium cepa* L.). *Saudi Journal of Biological Sciences*, 22: 398-403.
- Kumari K, Mathew BC, & Augusti KT. 1995. Antidiabetic and hypolipidemic effects of S-methyl cysteine sulphoxide isolated from *Allium cepa* L. *Indian Journal of Biochemistry and Biophysics*, 32: 49–54.
- Lewicki PP, Witrowa-Rajchert D, Pomaranska-Lazuka W & Nowak D. 1998. Rehydration properties of dried onion. *International Journal of Food Properties*, 1: 275-290.
- Mba OI, Kwofie EM, & Ngadi M. 2019. Kinetic modelling of polyphenol degradation during common beans soaking and cooking. *Heliyon*, 5: e01613.
- Mitra J, Shrivastava SL, & Rao PS. 2015. Characterization of vacuum dried onion slices. *Journal of Food Measurement and Characterization*, 9: 1-10.
- Olusola I. 2009. Effects of Drying on the Qualities of some Selected Vegetables. *International Journal of Engineering and Technology*, 1: 409.
- Ozgun M, Akpınar-Bayazit A, Ozcan T, & Yilmaz-Ersan L. 2011. Effect of dehydration on several physico-chemical properties and the antioxidant activity of Leeks (*Allium porrum* L.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 39:144–151.
- Ranganna S. 2001. *Handbook of Analysis and Quality Control for Fruit and Vegetable Products*, 2nd ed. Tata McGraw Hill Publications Co Ltd. Replika Press Pvt Ltd., Delhi
- Sangwan A, Kawatra A, & Sehgal S. 2010. Nutritional evaluation of onion powder dried using different drying methods. *Journal of Dairying, Foods and Home Sciences*, 29:151-153.

- Seifu M, Tola YB, Mohammed A, & Astatkie T. 2018. Effect of variety and drying temperature on physicochemical quality, functional property, and sensory acceptability of dried onion powder. *Food Science & Nutrition*, 6:1641-1649.
- Srivastava RP & Kumar S 2003. Fruits and vegetable preservation– principles and practices. International Book Distributing Co., India. Pages 360
- Tedesco I, Carbone V, Spagnuolo C, Minasi P, & Russo GL. 2015. Identification and quantification of flavonoids from two southern Italy cultivars of *Allium cepa* L. var. Tropea (red onion) and Montoro (copper onion) and their capacity to protect human erythrocytes from oxidative stress. *Journal of Agriculture and Food Chemistry*, 63: 5229–5238.
- Tyagi P, Chauhan AK, & Aparna 2020. Optimization and characterization of functional cookies with addition of *Tinospora cordifolia* as a source of bioactive phenolic antioxidants. *LWT-Food Science and Technology*, 130:109639
- Udensi, EA, & Okoronkwo KA. 2006. Effects of fermentation and germination on the physicochemical properties of *Mucuna cochinchinensis* protein isolate. *African Journal of Biotechnology*, 5: 896–900.