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Rheological, thermal, micro structural and functional properties of freeze dried onion powders as affected by sprouting

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ABSTRACT

The effect of sprouting on rheological, functional, thermal and micro structural properties of freeze dried onion powders obtained from four Indian onion cultivars (Punjab White, Punjab Naroya, PRO-6 and Commercial) were studied to assess the feasibility of using sprouting as a tool to imparting desirable thermal, functional and rheological properties in various food products. Sprouting showed an increase in protein, ash and fibre content with decrease in fat and carbohydrate content of onion powders. Functional properties (water solubility index, hygoscopicity, dispersibility and wettability) improved in sprouted powders as compared to the unsprouted powders. Sprouted onion powders showed lower elastic modulus (G′) and viscous modulus (G") in the linear viscoelastic region as compared to unsprouted powders. Sprouted powders recorded significantly ($P < 0.05$) higher glass transition temperature than the unsprouted powders. The morphological pattern which differed in both types of powders was determined by scanning electron microscopy. The increased protein content accounted for increase in particle size and solubility index thereby decreasing the viscosity as reflected by lower elastic (G′) modulus in sprouted onion powders. The improvements in composition and quality parameters were seen in all the cultivars tested showing that sprouting could be beneficial for product development across cultivars.

1. Introduction

Onion (*Allium cepa L*) crop of economical importance is a vegetable with great importance in daily cuisine across the world. Besides being an extra ordinarily nutritious vegetable, onion has been recognized for its functional properties as well as high antioxidant activity, which is related to its vitamin C content, anthocyanins, flavonoids (mainly quercetin and its conjugates)(Tedesco, Carbone, Spagnuolo, Minasi, & Russo, 2015). In recent years, onion consumption has tremendously increased due to its well established health benefits like, reducing coronary diseases and imparting anti-fungal and anti-bacterial properties (Insani et al., 2016). However, modern concept of healthy nutrition has led to the increased consumption of sprouted vegetable products as the content of secondary plant metabolites includingphenolic compounds, ascorbic acid and glucosinolates increase or is newly synthesized during sprouting (Oh, Song, & Min, 2017). Due to recognized health promoting benefits sprouted beans, cereals and vegetables have gained significance in human diet as a source of protein, mineral, dietary fibre, vitamins, ascorbic acid and phenolic compounds (Nam et al., 2015). As a result many sprouted vegetable products have emerged in the food market viz., *Brassicaceae* sprouts powder (Liu, Hou, Cardin, Marquart, & Dubat, 2017), soyabean sprouts (Yang, Gao, Yang, & Chen, 2015), broccoli sprouts (Tian, Xu, Liu, Xie, & Pan, 2016) and peanut sprout powder (Yu, Liu, Shi, Liu, & Wang, 2016). Onion crop because of its perishable natureand short shelf life undergoes process of sprouting which is considered to contribute 20–40%topost harvest storage losses in India (National Bank for Agriculture & Rural development, 2016). However, Majid, Dhatt, Sharma, Nayik, and Nanda (2016) reported that sprouted onions had higher protein content, ascorbic acid content, antioxidant activity, anthocyanin content and flavonoids than unsprouted ones and in turn this compositional change may influence the functional, thermal and rheological properties of the products subsequently developed from sprouted onions. Thus, there arises need of noble and efficient method to utilize these sprouted onions for the development of powder.

The various methods used to develop powder (spray drying, freeze drying) affects the surface composition of powder particles (particle size, densities, porosity and morphology) which determines their

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Table 1
Physico chemical and thermal properties of freeze dried unsprouted and sprouted onion powders from four Indian onion varieties.

	Punjab White		Punjab Naroya		PRO-6		Commercial	
	Unsprouted	Sprouted	Unsprouted	Sprouted	Unsprouted	Sprouted	Unsprouted	Sprouted
Moisture (%)	5.93 ± 0.11^{aP}	4.90 ± 0.19^{AQ}	5.18 ± 0.06^{bP}	4.94 ± 0.28^{AP}	3.26 ± 0.09^{cP}	3.18 ± 0.08^{BP}	4.93 ± 0.04^{dP}	4.33 ± 0.19^{cQ}
Protein (%)	8.57 ± 0.44^{aP}	9.64 ± 0.08^{AQ}	13.15 ± 0.06^{bP}	14.16 ± 0.91^{BP}	8.95 ± 0.18^{cQ}	10.32 ± 0.10^{CP}	11.74 ± 0.16^{cQ}	12.68 ± 0.11^{CP}
Ash (%)	1.85 ± 0.08^{aP}	1.93 ± 0.19^{AP}	2.89 ± 0.31^{bP}	3.16 ± 0.06^{BP}	2.54 ± 0.16^{cP}	2.75 ± 0.07^{CP}	1.93 ± 0.07^{cP}	2.04 ± 0.03^{CP}
Fibre (%)	3.87 ± 0.08^{aP}	4.25 ± 0.06^{AQ}	5.37 ± 0.11^{bQ}	6.08 ± 0.15^{BP}	4.74 ± 0.40^{bP}	5.19 ± 0.10^{CP}	4.69 ± 0.15^{cQ}	5.39 ± 0.10^{DP}
Fat (%)	0.65 ± 0.09^{aP}	$.47 \pm 0.07^{AQ}$	1.90 ± 0.36^{bP}	$.92 \pm 0.06^{AQ}$	0.97 ± 0.11^{bP}	$.81 \pm 0.10^{BP}$	$.82 \pm 0.04^{bP}$	$.61 \pm 0.11^{BQ}$
Total sugar (%)	23.72 ± 0.82^{aP}	22.68 ± 0.76^{AP}	26.62 ± 0.88^{bP}	25.81 ± 1.09^{BP}	24.18 ± 1.42^{bP}	23.74 ± 0.83^{BP}	24.35 ± 0.47^{bP}	24.16 ± 0.50^{BP}
Carbohydrate (%)	79.13 ± 0.95^{bP}	78.81 ± 1.31^{BP}	71.50 ± 0.87^{aP}	70.74 ± 1.29^{AP}	79.54 ± 0.74^{bP}	77.75 ± 1.06^{BP}	75.89 ± 0.66^{bP}	74.96 ± 0.97^{BP}
Energy (kcal/100 g)	358.65 ± 1.75^{aP}	356.03 ± 1.06^{AP}	355.70 ± 1.49^{bP}	347.88 ± 1.07^{BQ}	362.69 ± 0.93^{bP}	359.57 ± 0.67^{AP}	357.90 ± 0.79^{bP}	356.05 ± 1.26^{AP}
Water activity	0.31 ± 0.02^{aP}	$.26 \pm 0.06^{AP}$	$.23 \pm 0.05^{aP}$	$.19 \pm 0.06^{ABP}$	$.27 \pm 0.04^{aP}$	$.18 \pm 0.06^{ABCP}$	$.23 \pm 0.05^{aP}$	$.14 \pm 0.03^{BCP}$
Tg_1	0.30 ± 0.04^{aQ}	3.90 ± 0.08^{AP}	-8.20 ± 0.57^{aQ}	-0.30 ± 0.06^{BP}	$-.10 \pm 0.07^{aQ}$	7.40 ± 0.08^{CP}	$-.60 \pm 0.17^{bP}$	$-.40 \pm 0.02^{CP}$
Tg_m	0.40 ± 0.04^{aQ}	8.40 ± 0.15^{AP}	-7.30 ± 0.33^{bQ}	-0.50 ± 0.07^{BP}	$-.60 \pm 0.09^{cQ}$	10.70 ± 0.10^{CP}	-1.50 ± 0.03^{dQ}	-0.30 ± 0.03^{DP}
Tg_2	0.50 ± 0.02^{aQ}	17.20 ± 0.30^{AP}	-6.30 ± 0.35^{aQ}	-0.20 ± 0.10^{BP}	$-.10 \pm 0.03^{bQ}$	14.00 ± 0.14^{CP}	$-.40 \pm 0.05^{cQ}$	-0.10 ± 0.02^{CP}
ΔC_p	1.13 ± 0.05^{aQ}	1.33 ± 0.01^{AP}	$.28 \pm 0.05^{bP}$	$.34 \pm 0.05^{BP}$	$.07 \pm 0.03^{cQ}$	0.28 ± 0.04^{CP}	$.50 \pm 0.04^{dQ}$	1.36 ± 0.07^{CP}

Results are expressed as mean values ± standard deviations. Means in a row with same superscripts (a,b,c,d) for raw and (A,B,C,D) for sprouted are not significantly different ($P < 0.05$). Means in a row with same superscripts (P,Q) within a particular variety are not significantly different ($P < 0.05$).

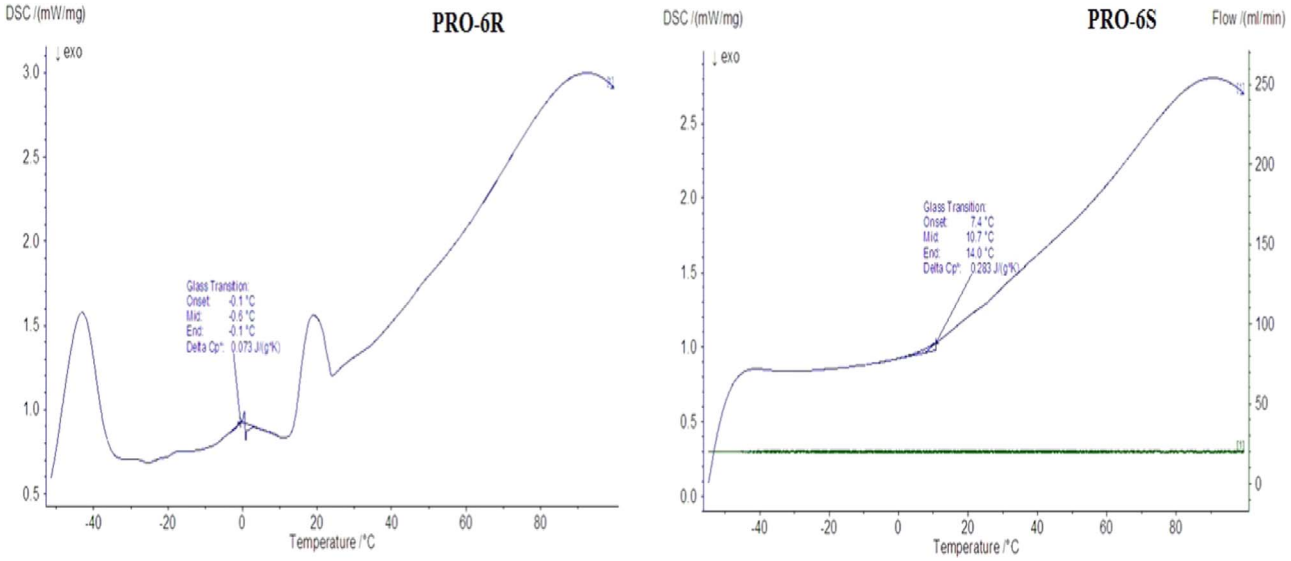

Fig. 1. The typical representative thermo gram of unsprouted (PRO-6R) and sprouted (PRO-6S) freeze dried onion powder.

hydrophobicity/hydrophilicity and in turn affect their rehydration properties which are characterized by sinking, dispersion, swelling, disintegration, wetting and solubilization or dissolution (Fitzpatrick et al., 2016). Freeze drying is considered suitable to preserve plant derived perishable and heat sensitive products like onions in the form of powder for their extended shelf life and convenience in usage, handling and transport (Kang, Yong, Maaruf, Osman, & Nazaruddin, 2014). Based on particle-particle interaction freeze dried food powders are found to exhibit different rheological state in their flow behaviour (Opalinski, Chutkowski, & Hassanpour, 2016). It is thus important to gain an insight of the reconstitutional and flow behaviour of food powders and the factors that affect them (Barbosa-canovas, Ortega-rivas, Juliano, & Yan, 2005). Freeze-dried powders possess either "rubbery" or "glassy" state depending on the final temperature and moisture content at a particular value of Tg that corresponds to the maximum freeze-concentrated amorphous matrix (Tg). The practical significance of the glass transition temperature as a physicochemical parameter that governs food processing, product properties, quality, and stability needs to be addressed (Goula, Karapantsios, Achilias, & Adamopoulos, 2008). Food processing whether thermal and non thermal processes, affect the natural structure and the composition of food powders. In recent years, the study of the microstructure of food powders has taken on increasing significance since; the structure of foods can have a profound influence on its nutritional value, rheology and functional attributes. Scanning electron microscopy is considered to be a powerful tool for visualizing the structure of food powders (James, 2009).

Keeping in mind the post harvest losses due to sprouting and to facilitate efficient utilization of sprouted onions, there is need for the development and characterization of freeze dried sprouted onion powders with respect to its nutrient composition, thermal properties, functional properties, rheological behaviour and micro structural properties which has not been reported so far.

2. Materials and methods

2.1. Sprouting of onions

Three Rabi season (crops grown during the winter season i.e. October to March) onion varieties (Punjab Naroya, Punjab white and PRO-6) were procured from Department of Vegetable Science, P.A.U Ludhiana, India. One commercial variety bought from local market was also stored, utilized and analyzed under similar conditions. The sprouting was carried out at an average light intensity of 64 lm, average relative humidity of 80.2% and average temperature of 15.22 °C for three weeks after which the onions attained the 8 cm sprout length.