Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(3): 120-124
Received: 18-03-2018
Accepted: 19-04-2018

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Rehydration properties of spray dried sweet orange juice

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Abstract
Spray drying is an important method used by the food industry in the production of powder from juice products. The quality of spray dried food depends on different factors of spray dryer operating systems. The objective of this study was to evaluate the influence of the process conditions on the rehydration properties of spray dried sweet orange juice. The effects of inlet air temperature (130, 140 and 150 °C), and maltodextrin concentration (6, 9, and 12%) on dispersability, wettability and solubility were evaluated using a Factorial completely randomised design (FCRD). Results revealed that the spray dried sweet orange juice powder obtained at 6% maltodextrin concentration with 150 °C temperature had the highest dispersibility (84.91).At 12% maltodextrin concentration with 150 °C temperature the highest wettability (304.66 s) was obtained and the highest solubility (93.33%) of spray dried powder was obtained at 6% maltodextrin concentration with 130 °C temperature.

Keywords: Rehydration, Dispersability, wettability, solubility

Introduction
Spray drying is the process of simultaneous atomization and desiccation of liquid matrix with distinctive rheological properties, in presence of hot drying medium to facilitate rapid moisture evaporation and result in dried particulate products (Tontul & Topuz, 2017) [29]. The underlying principle of spray drying is the convective mode of heat transfer between the atomized liquid feed and hot air at atmospheric pressure. In recent years, adoption of spray drying process in food industry to generate dried particulates and agglomerates increased exponentially especially in beverage sector as the fortification is essential in beverage matrices (Shishir & Chen, 2017) [28]. Characterization of spray dried powders is critical to define their end-use. The ability to rehydrate or reconstitute in water is an important quality attribute of spray dried powders (Kaderides & Goula, 2017) [15]. The key stages in rehydration are; wettability, dispersibility and solubility. Wettability defines penetrability of liquid into spray dried powders or agglomerates which helps in describing moisture content of final beverage. With respect to dispersibility, spray dried particulates ability to dissolve in water, while it this property demonstrates formation of lumps during rehydration. Solubility assesses the final condition under in which the powder constituents can be brought into solution or stable suspension. The rehydration properties of spray dried powders are function of the structural state of its proteins, whether in native, aggregated form or denatured (Chever, Mejean, Dolivet, Mei, Den Boer, Le Barzic, *et al*., 2017; Jafari, Ghalenoei, & Dehnad, 2017) [4, 13].
The reconstitution properties of spray-dried powder are essential due to their consideration in beverage preparation. In recent years, orange fruit juices are used most frequently in spray drying process. Ideally, spray-dried sweet orange juice powder should reconstitute instantly which is utilized as an antioxidant rich additive in food industry (Shishir & Chen, 2017; Verma & Singh, 2015) [28, 30]. However, sweet orange juice is most perishable product having pH of 3.70-4.60 which enables microbial growth and pectin methylesterase enzyme which degrades the inherent pectin. In addition, presence of high organic acids and low molecular weight amorphous sugar particles is a critical factor in controlled deposition of particle (Prasanna, Prabha, & Tharanathan, 2007) [21]. Spray-dried sweet orange juice powder can be utilized in fortification of food matrices. Variations in spray drying process parameters and additives type, concentration and dispersant has shown in potential improvements in functional and reconstitution properties such as solubility, wettability and dispersibility during food formulations (Rodríguez-Hernández, González-García, Grajales-Lagunes, Ruiz-Cabrera, & Abud-Archila, 2005; Yousefi, Emam-Djomeh, & Mousavi, 2011) [24, 31]. Spray dried powder is an essential ingredient in food formulations, includes reconstituted beverages and high protein

drinks, where their solubility is critical factor. Wettability is considered to be the critical step of the reconstitution process (Shishir & Chen, 2017) [28].

Due to lack of research on the reconstitution properties of sweet orange juice this study was carried out with the objective of evaluating the influence of spray drying operational conditions like inlet air temperature and maltodextrin concentration on the reconstitution properties like dispersability, wettability and solubility of spray drying sweet orange juice.

Materials and Methods

Spray drying

Spray drying involved spraying the sweet orange juice using two fluid nozzles at the pre-determined inlet air temperature and outlet air temperatures, feed pump rate and blower speed. The spray dryer parameters for the present investigation are tabulated in Table 1. For present research work, distilled-deionized water was pumped into the spray dryer to adjust the spray drying temperatures. The dryer was run at this condition for about 20 min before the feed was introduced. The feed was introduced into the spray dryer through feed pipe after adjusting the inlet and outlet air temperatures.

Sweet orange juice was extracted from screw press juice extractor, extracted juice was filtered. Sweet orange filtered juice was homogenised at 2000 rpm for 10 min. Maltodextrin solutions with different concentrations *viz.*, 6, 9 and 12% were prepared in 50 ml of hot water (45-50 °C). After the preparation of 50 ml of maltodextrin solution, it was added to 100 ml of filtered juice and again homogenisation was done at the same condition. Homogenised solution was spray dried with different inlet air temperatures of 130, 140 and 150 °C at feed flow rate of 2.5 $ml.min^{-1}$(5 rpm) at 1.5-2 $kg.cm^{-2}$ pressure.

Table 1: Spray dryer parameters

Sl. No.	Parameter			
1	Inlet air temperature (°C)	130	140	150
2	Outlet air temperature (°C)		70	
3	Feed flow rate (rpm)		5	
4	Blower speed (rpm)		2000	
5	Atomization pressure ($kg.cm^{-2}$)		1.5-2.0	

Rehydration properties of spray dried juice powder

The Rehydration properties such as, dispersibility, wettability and solubility of spray dried sweet orange juice powder are very important criteria for its acceptability. All the experiments in the study were analysied by Factorial completely randomised design (FCRD).

Dispersibility

The dispersibility of juice powder was measured according to the method reported by Jaya and Das (2004) [11] and Fonseca *et al.* (2011) [7].

$$\text{Dispersaility (\%)} = \frac{(w + a)s_p}{as_j}$$

Where,

a = Amount of juice powder used, g

w = Weight of water taken for reconstitution, g

s_p = Total solids present in juice powder, %

s_j = Per cent dry matter present in reconstituted juice after it has been passed through the sieve (150µ)

Wettability

The wettability of the powder was measured according to the method reported by Jinapong *et al.* (2008) [12].

Wettability (s) = Time in seconds necessary to achieve complete wetting

Solubility

The solubility of the product was measured according to the method reported by Zhang *et al.* (2013) [32] and Shittu and Lawal (2007) [27].

$$\text{Solubility (\%)} = \frac{10 \times m_2}{m_1} \times 100$$

Where,

m_1= Initial weight of sample, g

m_2= Final weight of sample, g

Result and Discussion

The results of the effect of processing conditions on rehydration properties such as solubility, wettability and dispersibility of spray dried sweet orange juice powder is presented here under. Values of different rehydration properties are shown in table 2.

Dispersibility

The dispersibility of spray dried sweet orange juice powder ranged from 83.46 to 84.91% at 6% maltodextrin concentration and at different inlet air temperatures, where as at 9 and 12% maltodextrin concentrations, the dispersibility ranged from 80.80 to 83.05% and from 76.76 to 78.10%, respectively at different inlet air temperatures. In case of maltodextrin concentration and temperature interaction, it revealed that the spray dried sweet orange juice powder obtained at 6% maltodextrin concentration with 150 °C temperature had the highest dispersibility (84.91%) and spray dried sweet orange juicepowder obtained at 12% maltodextrin concentration with 130 °C temperature had the lowest dispersibility (76.76%).As the inlet air temperature and maltodextrn concentration increased from 130 to 150 °C and from 6 to 12% respectively, 6.42% reduction of dispersibility was found in spray dried sweet orange juice powder.

From fig.1a, it is revealed that the dispersibility increased with increase in inlet air temperature from 130 to 150 °C and this might be due to less moisture content at higher temperature and dispersibility decrease with increase in maltodextrin concentration from 6 to 12%. It is clear that a decrease in the maltodextrin concentration in the fruit juice slurry increased the dispersibility values of the spray dried sweet orange juice powder. This might be due to the presence of less amount of insoluble residue and formation of very few lumps as a result of the use of lower amount of additive i.e., maltodextrin (Abadio *et al.*, 2004) [1]. Patil *et al.* (2014) [20] reported similar results in guava powder stating that as the temperature increased from 170 to 185 °C, the dispersibility decreased from 87.32 to 92.68 % which was nearer to the present investigation values. Shittu and Lawal (2007) [27] also recorded 79.5 to 94.5% of dispersibility in powdered cocoa beverages.

Wettability

The wettability of spray dried sweet orange juice powder ranged from 277.33 to 288.66 s at 6% maltodextrin concentration and at different inlet air temperatures, whereas at 9 and 12% maltodextrin concentrations, the wettability ranged from 292.66 to 294.33 s and from 301.33 to 304.66 s, respectively at different inlet air temperatures. From the present investigation it was found that wettability of spray dried powder increased by 9.85% as the inlet air temperature and maltodextrin concentration increased from 130 to 150 °C and from 6 to 12% respectively. In case of maltodextrin concentration and temperature interaction, it was revealed that the spray dried sweet orange juice powder obtained at 12% maltodextrin concentration with 150 °C temperature had the highest wettability (304.66 s) and spray dried sweet orange juice powder obtained at 6% maltodextrin concentration with 130 °C temperature had the lowest wettability (277.33 s).

From the experiment, it is revealed that the wettability was increased with increase in inlet air temperature from 130 to 150 °C and increased with increase in maltodextrin concentration from 6 to 12% (Fig.1b). Increasing the inlet air temperature resulted in an increase in average time of wettability i.e., the decrease in wettability. The increase in average time of wettability as the inlet air temperature was increased resulted from the reduced product residual moisture content (Chegini and Ghobadian 2005) [2]. Other researchers also reported similar findings (Chegini and Taheri, 2013) [3] and this might be due to the formation of a hard surface layer over the powder particle at high temperature. This could prevent water molecules from diffusing through the particle. Consequently, it decreased the wettability of the particle (Fazaeli *et al.*, 2012) [6].

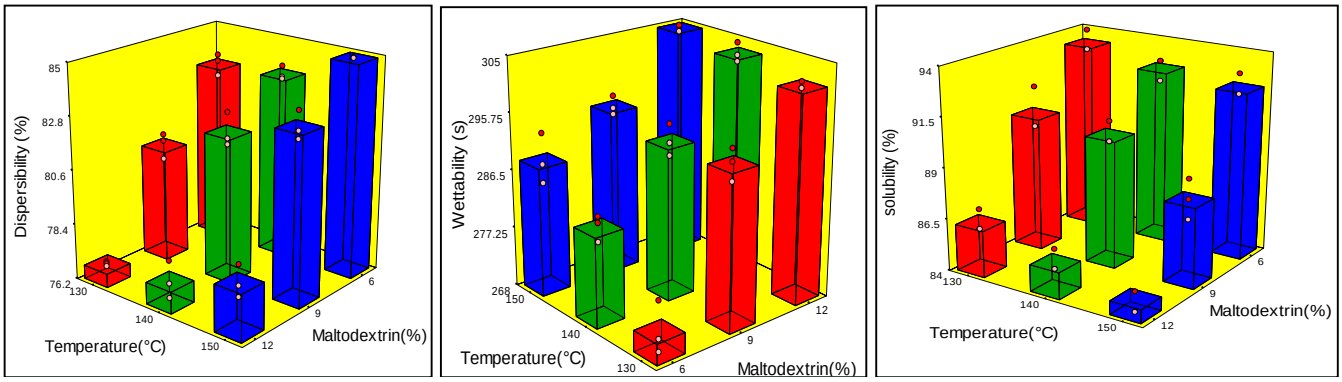
Solubility

The solubility of spray dried sweet orange juice powder ranged from 92.33 to 93.33% at 6% maltodextrin concentration and at different inlet air temperatures, whereas at 9 and 12% maltodextrin concentrations, the solubility ranged from 88.00 to 90.67% and from 84.66 to 86.33%, respectively at different inlet air temperatures. In case of maltodextrin concentration and temperature interaction, it was revealed that, the spray dried sweet orange juice powder obtained at 6% maltodextrin concentration with 130 °C temperature had the highest solubility (93.33%) and spray dried sweet orange juice powder obtained at 12% maltodextrin concentration with 150 °C temperature had the lowest solubility (84.66%).

When the inlet air temperature and maltodextrin concentration was increased from 130 to 150 °C and from 6 to 12%, the reduction of solubility was found to be 9.26%. From Fig.1c, it is very clear that there was decrease in solubility with increase in inlet air temperature from 130 to 150 °C and with increase in maltodextrin concentration from 6 to 12%. When the inlet air temperature and maltodextrin concentration was increased from 130 to 150 °C and from 6 to 12%, the reduction of solubility was found to be 9.26%. Sahin-Nadeem *et al.* (2013) [26] observed similar results as increasing the inlet air temperature caused a decrease in the solubility of the samples. Similar findings were also observed by Quek *et al.* (2007) [22] for watermelon powder. This might be due to the higher tendency of agglomeration at lower inlet temperatures, which resulted in more rehydration of the powders. Roustapour *et al.* (2012) [23] reported 80 to 95% of solubility in pomegranate juice powder, which was nearer to the present investigation. Yousefi *et al.* (2011) [31] also observed that the solubility was strongly affected by the concentration of carrying agent.

Table 2: Rehydration properties of spray dried sweet orange juice powder from different treatments

MD conc. (%)	Temp. (° C)	Dispersibility (%)	Wettability (s)	Solubility (%)
	130	83.46	277.33	93.33
6	140	83.65	282.33	92.67
	150	84.91	288.66	92.33
	130	80.80	292.33	90.67
9	140	82.10	292.66	90.32
	150	83.05	294.33	88.00
	130	76.76	301.33	86.33
12	140	77.09	303.33	85.32
	150	78.10	304.66	84.66
MD conc = Maltodextrin concentration; Temp. = Temperature; No. of replications = 3				



a. **b.** **c.**

Fig 1: Effect of inlet air temperature and maltodextrin concentration on dispersability (a), Wettability (b) and solubility (c) of spray dried sweet orange juice powder.

Conclusion

- The highest dispersibility (84.91) was found at 6% maltodextrin concentration with 150 °C temperature. spray dried sweet orange juice powder obtained at 12% maltodextrin concentration with 150 °C temperature had the highest wettability (304.66 s). At 6% maltodextrin concentration with 130 °C temperature, spray dried powder had the highest solubility (93.33%).
- Average redydration properties of spray dried sweet orange juice powder *viz.*, dispersibility, wettability and solubility recorded 81.10%, 326.69 s and 89.29%, respectively.
- The fresh sweet orange juice is not available in the market round the year. So it is essential to convert the sweet orange juice into powder to enhance its shelf-life of the sweet orange juice without compromising its nutritional qualities and sensory characteristics.

Reference

1. Abadio FDB, Domingues AM, Borges SV, Oliveira VM. Physical properties of powdered pineapple (*Ananas comosus*) juice effect of malt dextrin concentration and atomization speed. J Food. Eng. 2004; 64(3):285-287.
2. Chegini GR, Ghobadian B. Effect of spray-drying conditions on physical properties of orange juice powder. Drying Technol. 2005; 23(5):657-668.
3. Chegini GR, Taheri M. Whey powder: Process technology and physical properties: A review. J Middle-East Scientific Res. 2013; 13(10):1377-1387.
4. Chever S, Mejean S, Dolivet A, Mei F, Den Boer C, Le Barzic G *et al*. Agglomeration during spray drying: Physical and rehydration properties of whole milk/sugar mixture powders. LWT-Food Science and Technology. 2017; 83:33-41.
5. Favaro-Trindade CS, Santana AS, Monterrey-Quintero ES, Trindade MA, Netto FM. The use of spray drying technology to reduce bitter taste of casein hydrolysate. Food Hydrocolloids. 2010; 24:336-340.
6. Fazaeli M, Emam-Djomeh Z, Ashtari AK, Mahmoud O. Effect of spray drying conditions and feed composition on the physical properties of black mulberry juice powder. Food Bioprod. Process. 2012; 90(4):667-675.
7. Fonseca CR, Bento MSG, Quintero ES, Oliveira CAF. Physical properties of goat milk powder with soy lecithin added before spray drying. Int. J Food Sci. Technol. 2011; 46(3):608-611.
8. Goula AM, Adamopoulos KG. Influence of spray drying conditions on residue accumulation_Simulation using CFD. Drying Technology, 2004.
9. Goula AM, Adamopoulous KG, Kazakis NA. Influence of spray drying conditions on tomato powder properties. Drying Technol. 2004; 22(5):1129-1151.
10. Horszwald A, Julien H, Andlauer W. Characterisation of aronia powders obtained by different drying processes. Food Chem. 2013; 141(3):2858-63.
11. Jaya S, Das H. Effect of maltodextrin, glycerol monostearate and tricalcium phosphate on vacuum dried mango powder properties. J Food Eng. 2004; 63(2):125-134.
12. Jinapong N, Suphantharika M, Jamnong P. Production of instant soymilk powders by ultrafiltration, spray drying and fluidized bed agglomeration. J Food Eng. 2008; 84(2):194-205.
13. Jafari SM, Ghalenoei MG, Dehnad D. Influence of spray drying on water solubility index, apparent density, and anthocyanin content of pomegranate juice powder. Powder Technology. 2017; 311:59-65.
14. Krinsky NI, Johnson EJ. Carotenoid actions and their relation to health & disease. Molecular Aspects of Medicines. 2005; 26(1):459-416.
15. Kaderides K, Goula AM. Development and characterization of a new encapsulating agent from orange juice by-products. Food Research International. 2017; 100:612-622.
16. Langrish TAG, Chan WC, Kota K. Comparison of maltodextrin and skim milk wall deposition rates in a pilot-scale spra dryer. Powder Technology. 2007; 179:83-89.
17. Martinelli L, Gabas AL, Telis-Romero J. Thermodynamic and quality properties of lemon juice powder as affected by maltodextrin and arabic gum. Drying Technology. 2007; 25:2035-2045.
18. Milind P, Dev C. Orange: Range of benefits: A review. Int. Res. J Pharm. 2012; 3(7):59-63.
19. Montgomery DC. Design and Analysis of Experiments. John Wiley and Sons, Inc, New York, 2001.
20. Patil V, Chauhan KA, Singh PR. Optimization of the spray-drying process for developing guava powder using response surface methodology. Pow. Technol. 2014; 253:230-236.
21. Prasanna V, Prabha T, Tharanathan R. Fruit ripening phenomena–an overview. Critical Reviews in Food Science and Nutrition. 2007; 47(1):1-19.
22. Quek SY, Chok NK, Swedlund P. The physico-chemical properties of spray dried watermelon powders. Chem. Eng. Process. 2007; 46(5):386-392.
23. Roustapour OR, Maftoon AN, Sarshar M. Determination of pomegranate juice powder properties produced by a pilot plant spray dryer with a two-fluid nozzle. Drying Technol. 2012; 30(16):1906-1917.
24. Rodríguez-Hernández G, González-García R, Grajales-Lagunes A, Ruiz-Cabrera M, Abud-Archila M. Spray-drying of cactus pear juice (*Opuntia streptacantha*): Effect on the physicochemical properties of powder and reconstituted product. Drying Technology. 2005; 23(4):955-973.
25. Sagar VR, Suresh KP. Recent advances in drying and dehydration of fruits and vegetables: A review. J Food Sci. Technol. 2010; 47(1):15-26.
26. Sahin-Nadeem H, Dincer C, Torun M, Topuz A, Ozdemir F. Influence of inlet air temperature and carrier material on the production of instant soluble sage (*Salvia fruticosa* Miller) by spray drying. J Food. Sci. Technol. 2013; 52(1):31-38.
27. Shittu TA, Lawal MO. Factors affecting instant properties of powdered cocoa beverages. Food Chem. 2007; 100(1):91-98.
28. Shishir MRI, Chen W. Trends of spray drying: A critical review on drying of fruit and vegetable juices. Trends in Food Science & Technology, 2017.
29. Tontul I, Topuz A. Spray-drying of fruit and vegetable juices: Effect of drying conditions on the product yield and physical properties. Trends in Food Science & Technology, 2017.
30. Verma A, Singh SV. Spray drying of fruit and vegetable juices-a review. Critical Reviews in Food Science and Nutrition. 2015; *55*(5):701-719.
31. Yousefi S, Emam-Djomeh Z, Mousavi S. Effect of carrier type and spray drying on the physicochemical properties of powdered and reconstituted pomegranate juice (*Punica*

granatum L.). Journal of food science and technology. 2011; 48(6):677-684.
32. Zhang H, Xia W, Xu Y, Jiang Q, Wang C, Wang W. Effects of spray-drying operational parameters on the quality of freshwater mussel powder. Food Bioprod. Process. 2013; 91(3):242-248.