Effect of different Drying Methods on Physicochemical Properties of Orange (*Citrus raticulata*) Peel Powder

Medha Sharma, Anit Kumar*, Charu Singh and Vivek Kumar*

Department of Food Technology, Harcourt Butler Technical University, Nawabganj, Kanpur, Uttar Pradesh-208002, India
E-mail: viveksachan99@rediffmail.com, anitkumarsingh09@gmail.com

Abstract—*India is the third largest producer of orange in the world contributing 52.01 lakh tones/annum in which Maharashtra is the leading state which accounts 1117.5 MT/annum. The peeling of orange generates wastage about 16% of peels and 84% of finished product. Orange is the fruit of the citrus species Citrus reticulate in the family Rutaceae. Peel is the main by-product obtained from orange fruit juice processing industry. Peel is rich in many bioactive components including antioxidant, anti-inflammatory, anti-carcinogenic and anti-atherosclerosis activities and contains significant amounts of phenolic compounds especially phenolic acids and flavonoids. In present study orange peel is dried in two drying techniques i.e hot air drying and freeze drying. Orange peel powder was examined for physicochemical properties. Among two combinations, freeze air dried sample showed significantly good physicochemical properties such as color, moisture content, water activity andFTIR as compared to hot air dried sample. It can be considered as a potential material for food preservatives as an edible fruit and vegetable coating for industrial purpose as well as farm level.*

Keywords: *Physicochemical properties, Freeze drying, Hot air drying and Orange peel powder.*

1. Introduction

Citrus is an ancient crop, with records of human cultivation extending back to at least 2100 BC (Moore, 2001). Citrus cultivation dates back to many centuries. South China and Assam are the origin of many citrus fruits. The citrus fruits include lime, lemons, and oranges. Limes, lemons and citrus reticulate are indigenous to Assam (Bhattacharya and Dutta, 1949). Among the major orange producing countries of the world, Brazil is the country at the first position with production area of 729583 in ha and total production on MT of 18012560. America is at the second position in terms of area and production with 250582 ha and 8166480 Mt in production. China occupies the third position with total area of 475000 in ha and 6500000 MT in production. India is at the fourth position with total production and productivity of orange of 334939 of ha and 3886198 in MT. Annual production of orange in world reached 29 million tonnes in 2013 and the annual growth rate was around 2.48 percent from 2000 to 2013 (FAOSTAT et al., 2016). The other countries having good area and production capacity includes Mexico, Spain and Egypt (NHB, 2015).

The processing industry creates a large amount of waste by-product in the form of peel, seeds, rag (the membranes between the citrus segments) and pulp (juice sacs), representing 50-60 percent of the whole fruit being discarded after juicing (Zaker et al., 2017). Orange peel is a waste produced in orange juice companies in high amounts each year. Even though there are several uses for this waste, juice companies would certainly benefit from the production of high value products from this waste. Waste conversion into value added materials is a growing subject due to environmental concerns. The maintenance of the quality of fresh produce is still a major challenge for the food industry. Utilization of orange (*Citrus sinesis*) peel powder as a source of dietary fibre and its effect on the cake quality attributes.

Orange peel contains significant amounts of phenolic compounds especially phenolic acids and flavonoids, thus it can be considered as a potential material for the food preservatives (Rafiq et al., 2018). Orange peel extract contains numerous flavonoids, including polymethoxylated flavones, glycosylated flavones and many other different phenolic acids, along with related derivatives. According to Milind et al. (2012), orange fruit peel contains flavone glycosides (neohesperidin, naringin, hesperidin, narirutin), triterpene (limonene, citrol), pigments (anthocyanin, β-cryptoxanthin, crytpoxanthin, zeaxanthin and rutin), flavones (tangeretin and nobiletin), flavonoids (citacridone, citbrasine and noradrenaline). Citrus flavonoids contain various bioactivities, including antioxidant, anti-inflammatory, anti-carcinogenic and anti-atherosclerosis activities.

Orange peel is the primary waste fraction amounting to almost 50% of the fruit mass. In food industries there is limited utilization of orange waste peel. So, this research will help in finding a solution to decrease the wastage of oranges by product by increasing the utilizationof the peel powder. The objectives of this research wereto prepare orange peel powder by hot air and freeze dryer and compared between them on the basis of physiochemical properties.

2. Materials and methods

2.1 Materials

Oranges (*Citrus raticulata*) were purchased from Kanpur Big Bazaar market.

2.2 Preparation of orange peel powder

Orange peel was dried in hot air oven (Yorco hot air oven, New Delhi) and freezes dryer (FreeZone 2.5, Labconco, USA) at 58^{o}C for 24 hours and -51^{0}C for 30 hours at approx 0.045 mBar pressure, respectively. A grinder mixer and sieve (40 mash size) was used in this study for homogeneous distribution of peel powder (Zaker, 2016).

2.3 Measurement of color

Color of the samples were evaluated using a handheld colorimeter (Chroma meter, CR-400, Konica Minolta Optics, Japan). CIE L* represents lightness, a* represents redness and b* represents yellowness were evaluated (Garau et al., 2007).

2.4 Moisture content

Moisture content was determined by AOAC (2000) method.

2.5 Water activity

Water activity was measured using water activity meter (Model Series 3 TE, Aqua Lab, USA). Prior to the measurement the samples were tempered to 25^{o}C (Raju and Pal, 2011).

2.6 Fourier transform infrared (FTIR) spectroscopy analysis

The absorption spectra of samples using FTIR spectrophotometer (ALPHA Bruker), were acquired at 4 cm^{-1} resolution, and 24 scans of each sample in the wave number range of 6000–400 cm^{-1}. The spectrum of pure ethanol was used as the background. Spectra were collected in duplicate and used for multivariate analysis (Paradkar and Irudayaraj, 2002).

2.7 Statistical analysis

All experiments were performed in duplicate and values are mentioned in mean and standard deviation by using the statistical program SPSS (version 24) (Kumar et al., 2019).

3. Results and Discussion

3.1 Orange peel powder preparation

Oranges were brought from Big Bazaar market which was of the same quality that is used for coating. Best practices were used to choose oranges i.e., same shape, size, and maturity index. Peel were extracted from oranges and cleaned from fresh water. Freeze dried orange peel powder and hot air dried orange peel powder has illustrated in Figure 1 and Figure 2 respectively.

Fig. 1 Freeze dried peel powder

Fig. 2 Hot air dried peel powder

3.2 Moisture content analysis

Moisture content of freeze dried and hot air dried peel powder was 9.12% and 10.34% respectively (Table 1). Moisture content of orange peel powder available in market is around 10%. Therefore, in this experiment, orange peel powder by using hot air drying and freeze drying satisfied the moisture percent present in commercial peel powder. Drying time was significantly more in freeze drying than hot air drying. This result could be due to the vaporization of moisture in freeze drying, which was slower than hot air drying. Mass transfer within the peel powder should be rapid during hot air drying because a large vapor pressure produced by air on the surface of powder. In freeze drying production of peel powder was of better quality because it protects the primary structure of food and does minimal reduction to quality of food (Ratti, 2001; Park et al., 2016).

Table 1 Moisture content of orange peel powder

S. No.	Sample	Moisture Content (%)
1	FDOPP	9.12± 1.25
2	HDOPP	10.34± 0.79

Values are in mean ± SD, where n=2

3.3 Water activity analysis

The water activity of freeze dried and hot air dried orange peel powder were 0.17 and 0.42 respectively as shown in Table 2. Water activity of HDOPP was higher as compared to FDOPP, it may be due to low moisture content was available in FDOPP.

ISBN: 978-93-85822-93-3

Table 2 Water activity of orange peel powder

S. No.	Sample	Water activity (a_w)
1	FDOPP	0.17 ± 0.003
2	HDOPP	0.42 ± 0.003

Values are in mean ± SD, where n=2

3.4 Color analysis

Color of freeze dried and hot air dried powder was determined using digital colorimeter. FDOPP represented a higher value of lightness (L*) and yellowness (b*) and redness (a*) than HDOPP (Figure 3). Bright yellow color was observed in freeze dried sample because less heat treatment was provided as compared to HDOPP. The lower value of L* represented the low lightness in the hot air dried sample as compared to freeze dried sample. This is probably due to hot air directly exposed on peel surface during the drying process. The a* value (redness) was higher in freeze-dried samples than those in hot air-dried samples, similar to the L* value. The browning, which was higher in hot air dried sample, may be responsible for this (Caparino et al., 2012). The b* values (yellowness) were lower in hot dried sample than freeze dried sample. Yellowness showed a slight decrease in its value as temperature increased as a result of generation of brown products due to non-enzymatic reaction. Similar result was shown byLenaerts et al. (2018). ΔE represented the overall change in the color of sample. ΔE was significantly higher in hot air dried sample as compared to freeze dried sample.

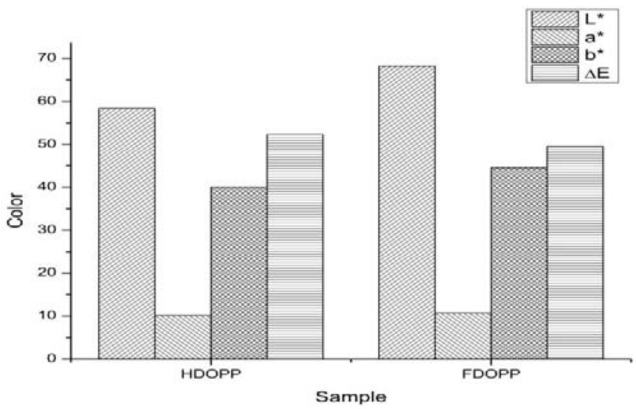

Fig. 3: Color analysis of hot air dried and freeze dried orange peel powder

3.5 FTIR analysis

The FTIR spectra of freeze dried andhot air dried samples are shown in Figure 4 and 5 respectively. In the spectrum, the peak at 3285.3 cm^{-1} corresponds to the O-H stretching of alcohol in both samples and also denoted the hydroxyl functional group.This change in -OH interaction is exhibited by miscible blends that show extensive phase mixing. The peak at 1680 represents the alkenyl C=C stretch this is indicative of the double bonds. A peak at 1055 represents the Cyclohexane ring vibrations Methyne (>C -). A peak at 3600 represent nonbonded hydroxy group, OH stretch in Figure 4. A peak at 1580 represents aromatic ring stretch (C=C-C) which is high in freeze dried sample (Coates, 2000). A peak at 1000 represents the aliphatic fluoro compounds, C-F stretch which represents its polar nature. A slight increase in the intensity of the band at 1750 (C=O, amide) can be observed in the freeze dried sample, which can be a representative of a strong interaction between the compounds of orange peel powder. Similar results were explained by (Coates, 2000).

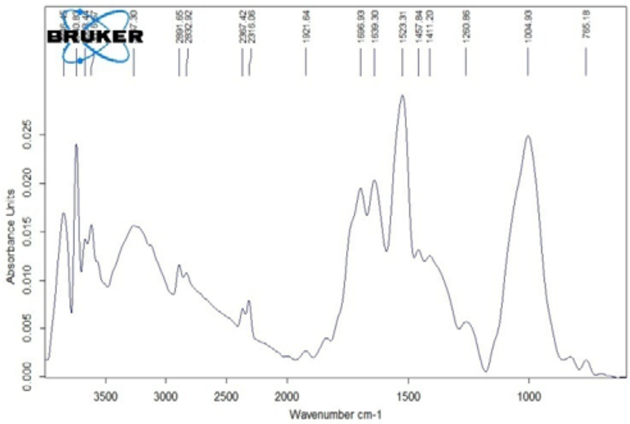

Fig. 4 FTIR spectrum of freeze dried orange peel powder

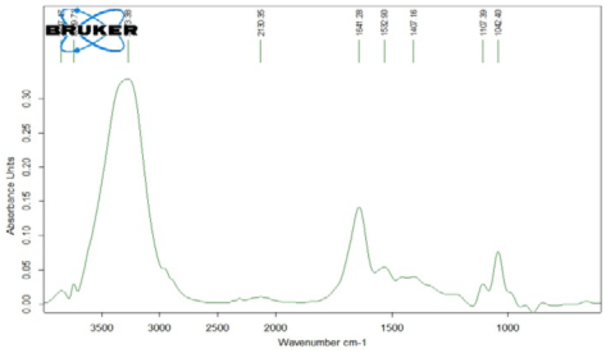

Fig. 5: FTIR spectrum of hot air dried orange peel powder

Conclusions

In this study freeze dried orange peel powder was compared with hot air dried orange peel powder. Results were significantly better for freeze dried orange peel powder as compared to hot air dried orange peel powder. Hence, freeze dried powder can be a potential material as it gives good results. In freeze drying, orangepeelsdoes not face any heat treatment, so the retention of bioactive compounds may retain more in freeze dried peel powder as compare to hot air drying. Hence, it can be concluded that the effect of freeze drying on orange peel powder can be a potential technique for making orange peel powder.

Declaration of conflict of interest

Authors declare no conflict of interests.

ISBN: 978-93-85822-93-3

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Acknowledgements

The authors express their sincere appreciation to Department of Food Technology, Harcourt Butler Technical University, Kanpur, India for supporting the research study.

References

[1] Acosta E (2009) Bioavailability of nanoparticles in nutrient and Nutraceutical delivery. Current Opinion in Colloid & Interface Science, 14: 3-15.

[2] Alfano EH, Crosta T, Martinez MJ, Pérez OE, &Farías ME (2017) Submicron O/W dispersions embedded into modified waxy maize starch based matrix: Rheological and microstructural characterization. Food hydrocolloids, 67:120-129.

[3] AOAC. (2000). AOAC official method 996.06, Moisture content. In Official methods of analysis of AOAC international (17th ed., pp. 20–24). Maryland: AOAC International.

[4] Bhattacharya SC and Dutta S (1949) Classification of citrus fruits of Assam. Directorate of agriculture, Assam. 40.

[5] Caparino OA, Tang J, Nindo CI, Sablani SS, Powers JR, &Fellman JK (2012) Effect of drying methods on the physical properties and microstructures of mango (Philippine 'Carabao'var.) powder. Journal of Food Engineering, 111(1): 135-148.

[6] Coates J (2000) Interpretation of Infrared Spectra, A Practical Approach. Encyclopedia of Analytical Chemistry R.A. Meyers (Ed.) pp. 10815–10837

[7] FAO Statistics (2014) Top Production of Oranges, 2014 – choose "Production, Crops, World" United Nations, Food and Agricultural Organization.

[8] Garau MC, Simal S, RosselloC &Femenia A (2007) Effect of air-drying temperature on physico-chemical properties of dietary fibre and antioxidant capacity of orange (Citrus aurantium v. Canoneta) by-products. Food chemistry, 104(3): 1014-1024.

[9] Kumar, A., Sehrawat, R. and Saxena, D. C. (2019) Development of pakoda using semi-automatic pakoda making machine: thermal, rheological, physicochemical and sensory properties. Journal of The Institution of Engineers (India): Series A, 8 (29): 1-7. https://doi.org/10.1007/s40030-019-00385-9

[10] Lenaerts S, Van Der Borght M, Callens A & Van Campenhout L (2018) Suitability of microwave drying for mealworms (Tenebrio molitor) as alternative to freeze drying: Impact on nutritional quality and colour. Food chemistry, 254, 129-136.

[11] Milind P, & Dev C (2012) Orange: range of benefits. International Research Journal Pharmacutical, 3(7):59-63.

[12] Moore GA (2001) Oranges and lemons: clues to the taxonomy of citrus from molecular markers. Trends Genet.m, 17 (9) :536-340.

[13] Paradkar MM, and Irudayaraj, J (2002) Determination of Cholesterol in Dairy Products Using Infrared Techniques: 1. FTIR Spectroscopy. International Journal of Dairy Technology, 55(3): 127-132.

[14] Park H J, Lee Y, &Eun JB (2016) Physicochemical characteristics of kimchi powder manufactured by hot air drying and freeze drying. Biocatalysis and Agricultural Biotechnology, 5, 193-198.

[15] Radi M, Akhavan-Darabi S, Akhavan HR, &Amiri S (2018) The use of orange peel essential oil microdispersion and nanodispersion in pectin-based coating to extend the shelf life of fresh-cut orange. Journal of Food Processing and Preservation, 42(2):134-141.

[16] Raju PN and Pal D (2011) Effect of Bulking Agents on the Quality of Artificially Sweetened Misti Dahi (Caramel Colored Sweetened Yoghurt) Prepared from Reduced Fat Buffalo Milk. LWT- Food Science and Technology, 44 (9): 1835-1843.

[17] Zaker MA, Sawate AR, Patil BM, Sadawarte SK And Kshirsagar RB (2017) Utilization of orange (Citrus sinesis) peel powder as a source of dietary fibre and its effect on the cake quality attributes. Department of Food Engineering and Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidhyapeeth, PARBHANI (M.S.) INDIA, 13: 56-61.