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PRELIMINARY INVESTIGATIONS INTO THE PRODUCTION OF FREEZE-DRIED PUMPKIN POWDERS

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Abstract: The production of freeze dried pumpkin powders was investigated using five cultivars of pumpkins. Pumpkin purees were frozen then dried in a vacuum freeze drier. The resulting dried 'cakes' were pulverized to produce powders, which were compared with purees dried in an oven at 65°C. For all cultivars, freeze dried powders were superior in colour compared with air dried samples. Colour attributes and selected physico-chemical results for the different cultivars are presented.

1.0 Introduction and Objectives

Dehydrated fruit and vegetable powders can be used in many products, including instant soups, snacks and in bakery and beverage applications. The production of a dried pumpkin powder or flour presents an opportunity to add value to this carotenoid-rich fruit, which is also high in carbohydrate and minerals. Hot air drying of pumpkin slices often leads to severe discoloration and hardening of slices to a point where reconstitution or pulverizing to a powdered form are difficult. Several researchers have therefore investigated the impact of several types of drying pre-treatments (such as blanching, osmotic treatments, sulphiting and enzymatic treatments) to alleviate deleterious changes which may occur during hot air drying (Arevalo-Pinedo and Murr, 2007; Falade and Shogaolu, 2010; Konopacka et al. 2010; Lee and Lim, 2011; Olurin et al. 2012). Some authors have investigated alternative drying methods such as spray drying, vacuum and vacuum-microwave as a means to create higher quality dried pumpkin pieces and powders (Nawirska et al., 2009; Shavakhi et al., 2011). In work done regionally, Harrynanan and Sankat (2013) investigated the foam-mat drying of a locally available pumpkin hybrid as a means to produce a dried porous foam which could be easily converted to a powdered form. Harrynanan and Sankat (2013) reported that pumpkin puree foamed using glycerol monostearate together with methyl cellulose stabilizer could be dried at 60°C to produce porous 'mats', which could be easily blended into powders. They reported very little changes in colour between the purees and dried mats, adding that the foaming procedure also enhanced drying rate.

This work seeks to advance the knowledge on the production of dried pumpkin powders from regional and local cultivars of pumpkins and will investigate the feasibility of using vacuum-freeze drying as a method to produce high quality pumpkin powders. The drying of the material takes place while the material is frozen and consists of two stages; the sublimation stage during which product shape is maintained, and the secondary drying stage which removes unfrozen water. The potential advantage of this method of drying would be high quality powders free from any added ingredients and drying agents (Que et al., 2008; Dirim and Caliskan, 2012). This present project forms part of a larger body of work being conducted at the Food Science and Technology Unit at the Department of Chemical Engineering, investigating the freeze drying of fruits and vegetables to produce ready-to-eat snacks and dried powders. The objectives of this study were to:

- Establish the feasibility and suitability of freeze drying as a method of producing pumpkin powders from 5 pumpkin cultivars.
- Compare the quality of freeze-dried powders to those obtained using conventional hot air oven-drying.

2.0 Materials and Methods

2.1 Raw material handling and preparation

Five (5) pumpkin *(Cucurbita maxima* Duch.) cultivars were evaluated: Future NP-999 (imported Chinese variety), Bodles Globe (Jamaican variety), CES STARZ (a new variety developed by the Ministry of Food Production, Trinidad, larger fruit), Crapaud Back (Trinidad) and an unidentified local cultivar with a smooth skin, called Smooth Skin. Cultivars Future NP-999, Bodles Globe and CES STARZ were obtained through a specially funded Project*. These pumpkins were grown at the University Field Station, Valsayn, Trinidad, over the period 2013 to 2014. Crapaud Back and Smooth Skin pumpkins were purchased at the local market. Pumpkins were stored in a refrigerated walk-in chiller (4°C) located at the Food Processing Laboratory at Department of Chemical Engineering until it was ready for use. The fresh fruit characteristics are given in Table 1. Pumpkins were cut, peeled and seeds removed before being sliced using a Hobart Slicer (Model 1612, Ohio USA). The pumpkin slices were pureed in a Model CB16, Waring Commercial blender (Connecticut, USA). For freeze drying, 30g samples of pumpkin puree were plated into plastic Petri dishes which were then placed in resealable freezer bags and frozen for a minimum of 48 h at -18°C in a chest-type freezer. For samples to be air dried, 30g each of pureed pumpkin was placed into glass petri dishes and dried immediately.

2.2 Drying methods

Freeze drying of frozen samples was carried out on duplicate samples in a laboratory-scale vacuum freeze drying unit (Benhay SB-4, UK) under vacuum (13.3 Pa) at a condenser temperature of -44°C and heating temperature of 30°C (Dirim and Caliskan, 2012). Petri dishes containing samples were carefully placed inside the freeze dryer and drying was continued until constant weight was attained. This was determined from preliminary experiments to be 64h. To compare the quality of air-dried purees, separate pumpkin puree samples were dried in a UNITEMP Air Drying Cabinet (LTE Scientific Ltd., Greenfield, Oldham) for 9h at 65°C. The dried 'cakes' were pulverised in a laboratory blender to obtain powders which were stored in resealable plastic bags placed into sealed glass jars airtight glass jars until analysis.

2.3 Analytical methods

Before pureeing, the weight and dimensions of whole pumpkins and selected physical measurements of cut pumpkins were recorded. Pumpkin weight was measured using a platform scale. Sample weights (0.01±0.005g) were also measured using an Explorer Pro Balance, Model EP2102C (Ohaus Corporation, NJ, USA). Physio-chemical analyses were done in duplicate on the fresh pieces and pumpkin powders. Moisture content of the fresh and dried samples was measured using a Halogen Moisture Analyzer HB43-S (Mettler Toledo-AG, Zurich, Switzerland) set at 115°C. Water activity (a_w) was measured using an Aqua Lab CX-2 water activity meter (Decagon Devices Inco., Pullman, WA, USA). Flesh firmness was assessed using a Wagner penetrometer (Wagner Instruments, CT, USA) and flesh colour (L^*, a^*, b^*) was measured using a

Minolta Chroma Meter (Model CR-410, Minolta Corporation, NJ, USA). The maximum for “L^*” value is 100 (white) and the minimum is zero (black). Positive “a” value is red, negative “a” is green, while positive “b^*” value is yellow and negative “b^*” is blue. Hue angle (°), Chroma and Total colour difference (□E) between fresh and dried leaves were calculated as given in Equations 1 through 3.

$$Hue = Arc\tan\left(\frac{b^*}{a^*}\right) \tag{1}$$

$$Chroma = \sqrt{(a^{*2} + b^{*2})} \tag{2}$$

$$\Delta E = \sqrt{(L^*_0 - L^*)^2 + (a^*_0 - a^*)^2 + (b^*_0 - b^*)^2} \tag{3}$$

Total soluble solids, pH and titratable acidity of samples were determined by first blending an appropriate quantity of fresh pumpkin or powder in distilled water followed by filtering using Whatman filter paper (No. 2) to obtain a clear supernatant. Based on preliminary testing of procedure, a ratio of 1:5 (sample: water) was used for the fresh pumpkin samples (Rahman et al., 2013) and a 1:20 ratio was used for the powdered samples. Sample pH and total soluble solids (TSS) were determined using a Hanna pH/ORP Meter (Model HI 991002, Woonsocket RI, USA) and Abbe Mark III Refractometer (Reichert Analytical Instruments, New York, USA), respectively. Density (g/ml), wettability (s) and solubility (s) of freeze dried and air-dried powders were measured according to Dirim and Caliskan (2012). Percentage yield of dried powder was calculated based on the fresh weight as given in Equation (4):

$$\text{Yield (\%)} = \frac{\text{Weight of powder (g)}}{\text{Fresh Weight (g)}} \tag{4}$$

3.0 Results and Discussion

As given in Table 2, all oven dried cakes were discoloured and changed to a brown/grey colour with slight pumpkin odour. During air drying, the samples showed severe shrinkage, became very hard and developed cracks. The freeze dried cakes were found to maintain the colour of the fresh samples, with the cakes of Bodles Globe, Crapaud Back and Smooth Skin pumpkins being very attractive in colour. Freeze dried ‘cakes’ from all varieties except the Future NP-999 cultivar could be described as “spongy” in texture and were easily pulverized to fine powders using a blender. The cakes of Future NP-999 were somewhat sticky and produced grainy powders. Freeze dried cakes of Bodles Globe, Crapaud Back and Smooth Skin purees were deep orange in colour with the pumpkin odour in the Crapaud Back and Smooth Skin being described as “Strong”. Air dried samples darkened in colour and maintained only a slight pumpkin odour after drying. Dirim and Caliskan (2012) also noted the importance of visual appeal of powders, which affect marketability. Ideally, the colour of a dried product should remain unchanged after processing. Que et al. (2008) also reported severe browning of pumpkin slices during air drying at 70°C.

Selected characteristics of the fresh, freeze dried and air dried powders are given in Table 3. The average initial moisture content of the pumpkins was found to range from approximately 84% (wb) for Future NP-999 to 94% for Crapaud Back pumpkins. Initial water activity values were not significantly different in four varieties, but was higher in Smooth-Skin pumpkins, averaging 0.998. The moisture content of pumpkin samples of fresh and dried samples is given in Figure 2. Moisture content was reduced from an initial average of 89.3% wb to an average of

5.5% in freeze dried samples versus and average of 3.0% in oven-dried samples. Moisture content was significantly *($p \leq 0.05$)* affected by variety, drying method and a variety-method interaction. Initial water activity averaged 0.981. The water activity values of dried samples were found to be significantly affected by variety *($p \leq 0.05$)* but not by drying method. The water activity values for freeze-dried samples averaged 0.314, and 0.330 for air-dried samples. Dirim and Caliskan (2012) reported a decrease in moisture content of *Cucurbita moschata* purees from 92.3% to 3.9% after freeze drying. Water activity decreased from 0.988 to 0.197. Water activity is a measure of moisture that is available to microorganisms and designing a product with a water activity below 0.60 is considered an effective control measure (Montville and Matthews, 2005).

Colour L^*, a^*, b^* values were significantly affected by variety and drying method and there was a variety-treatment interaction effect for L^* and b^*values ($p \leq 0.001$). Hue angle (°) was affected by variety and drying method and the Chroma and □E values were affected by variety and drying method ($p \leq 0.001$). Colour difference values between fresh and dried samples support the overall results that the freeze dried powders were closer in colour value to the fresh samples when compared with oven dried powders (Table 3). On average, □*E* values for freeze dried samples averaged 12.1 while values for oven dried samples averaged 30.1. The initial pH of varieties ranged from 4.6 to 6.4, but the differences between the pumpkin varieties were not statistically significant. As also found by Que et al. (2008), air dried pumpkin powders were much darker than fresh and freeze-dried samples, and therefore had lower L^* values together with higher b^* values. Harrynanan and Sankat (2013) reported that the foaming process prior to oven drying of pumpkin purees resulted in a 30% increase in lightness. They reported a slight increase in Hue values (°) of foam-mat dried pumpkin powders during a 60-day storage period.

The pH of dried samples was significantly affected by variety and drying method and interaction *($p \leq 0.05$)*. Of the fresh samples, the total soluble solids content of fresh samples was highest in Smooth-skin pumpkins (5.25 %) and lowest in CES STARZ fruit (1.55 %). The total soluble solids content of dried samples was significantly affected by variety and drying method and interaction *($p \leq 0.05$)*. As expected, the soluble solids content of dried powders was very high as calculated on a fresh weight basis, with the values being higher in freeze dried samples.

Table 3 gives selected properties of powders obtained by freeze and air drying. The yield of pumpkin powder obtained for the freeze drying and air drying processes was found to vary with both variety and drying treatment *($p \leq 0.05$)*, with yields being consistently higher in freeze dried samples (Figure 1). Of the freeze dried samples, slightly higher yields of 8.6, 9.6 and 9.4% were obtained for the Future NP 999, Bodles Globe and CES STARZ varieties compared with 7.9 and 8.1% yield for Crapaud Back and Smooth Skin purees. Due to the very sweet odour emanating from the air dried samples during drying, it was suspected that caramelization of sugars could have been occurring during air drying. Wettability values of the dried powders ranged from 687 to 702 s. Values differed with variety ($p \leq 0.05$) but not by drying method. Solubility of powders ranged from 12 to 13.5 s and solubility was not affected by variety or drying method. Bulk, tapped and shaken density values given in Table 2 were affected by variety and drying treatment effect ($p \leq 0.001$). Bulk density values for freeze dried powders ranged from 0.18 to 0.26 g/ml and 0.22 to 0.39 g/ml for oven dried powders. Que et al. (2008) found that air dried pumpkin powders had higher solubility values when compared with freeze dried powders. As also found in this study, they also reported that air dried samples had higher bulk density values. Dirim and Caliskan (2012) noted that these properties are indicative of the reconstitutive capacity of powders. In that study, the bulk density of freeze dried pumpkin powder averaged 0.113 g/ml while solubility and wettability values averaged 710 s and 16 s, respectively.

4.0 Conclusions

While both freeze drying and air drying methods effectively reduced MC and lowered a_w, of pumpkin purees, the colour attributes were found to be superior in freeze dried samples compared with air-dried samples. Freeze dried 'cakes' from all varieties could be described as "Spongy" in texture and were easily pulverized using a blender. Air dried cakes suffered from shrinkage and cracking during drying. Freeze drying of pumpkin purees gave fine powders with noticeably improved colour and less granular texture than powders obtained using hot air drying. Appealing freeze-dried powders were obtained from the Bodles Globe, Crapaud Back and Smooth Skin pumpkins. Future NP-999 fruits produced the least favourable powders based on colour, odour and texture.

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References

Arévalo-Pinedo, A. and Xidieh Murr, F. (2007), "Influence of pre-treatments on the drying kinetics during vacuum drying of carrot and pumpkin", Journal of Food Engineering, Vol.80, No.1, pp.152-156.

Harrynanan, L. and Sankat, C. (2014), "Product quality attributes of foam-mat dried pumpkin powder", ISHS *Acta Horticulturae* 1047: III International Conference on Postharvest and Quality Management of Horticultural Products of Interest for Tropical Regions, Vol.1047, pp.323-330.

Konopacka, D., Seroczyńska, A., Korzeniewska, A., Jesionkowska, K., Niemirowicz-Szczytt, K. and Płocharski, W. (2010), "Studies on the usefulness of Cucurbita maxima for the production of ready-to-eat dried vegetable snacks with a high carotenoid content", LWT - Food Science and Technology, Vol.43, No.2, pp.302-309.

Lee, J. and Lim, L. (2011), "Osmo-dehydration pre-treatment for drying of pumpkin slice", *International Food Research Journal*, Vol.18, No.4, pp.1223-1230.

Nawirska, A., Figiel, A., Kucharska, A., Sokół-Łętowska, A. and Biesiada, A. (2009), "Drying kinetics and quality parameters of pumpkin slices dehydrated using different methods", *Journal of Food Engineering*, Vol.94, No.1, pp.14-20.

Nur Dirim, S., Çalışkan G. (2012), "Determination of the effect of freeze drying process on the production of pumpkin (Cucurbita moschata) puree powder and the powder properties", GIDA / The Journal of Food, Vol.37, No.4, pp.203-210.

Olurin, T., Adelekan, A. and Olosunde, W. (2012), "Mathematic modeling of drying characteristics of blanched field pumpkin (*Cucurbita pepo* L) slices", *Agric Eng Int: CIGR Journal*, Vol.14, No.4, pp.246-254.

Que, F., Mao, L., Fang, X. and Wu, T. (2008), "Comparison of hot air-drying and freeze-drying on the physicochemical properties and antioxidant activities of pumpkin (Cucurbita moschata Duch.) flours", International Journal of Food Science & Technology, Vol.43, No.7, pp.1195-1201.

Rahman, M., Miaruddin, M., Khan, M., Masud, M. and Begum, M. (2013), "Effect of Storage Periods on Postharvest Quality of Pumpkin", Bangladesh Journal of Agricultural Research, Vol.38, No.2, pp.247-255.

Shavakhi, F., Boo, H., Osman, A. and Ghazali, H. (2011), "Effects of Enzymatic Liquefaction, Maltodextrin Concentration, and Spray-Dryer Air Inlet Temperature on Pumpkin Powder Characteristics", Food Bioprocess Technol, Vol.5, No.7, pp.2837-2847.