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Effect of Pre-Treatment on the Physical Properties of Pumpkin Powder

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ABSTRACT

The preservation of pumpkin in powder form and ensuring its quality using different pre-treatments prior to drying is an important concern. The objective of this study is to determine the effect of pre-treatment on the physical properties of different parts of pumpkin powder. Different parts of pumpkin (skin, flesh, seed and unpeel) were pre-treated with blanching and soaking in Ca(OH)2 solution and then dried in air fryer at temperature of 80˚C and air flow 5.11m/s before being grounded and sieved (250 µm and 710 µm). The Ca(OH)2 pre-treatment showed low moisture content (5.51%-6.38%), low water activity (0.313-0.396), small particle size (112.04-213.46 µm) and high bulk density (505.51-375.75 kg/m3) in different portions of pumpkin powder as compare to blanching pre-treatment. For the color change, it is dependent on the parts of pumpkin and whether pre-treatment is applied. In conclusion, the pre-treatment with Ca(OH)2 could be recommended way in prior to drying of pumpkin ensuring the better quality of powder.

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INTRODUCTION

In Malaysia, the production of pumpkins increased from 3000 tons in year 1961 to 21306 tons in year 2012 (FAO, 2012). Among all the species, *Cucurbita moschata* as labu manis and *Cucurbita moschata Duchesne* as labu loceng are the most common cultivated in Malaysia (Norshazila *et al*., 2014). Pumpkins are rich in β-carotene, which could prevent attack from certain types of cancers (See *et al*., 2007) and cardiovascular diseases (Gaziano *et al*., 1992).

Nowadays, pumpkin powder is the major product of pumpkin fruit in processing, since it can be stored for a long time and used in manufacturing of formulated foods (Que *et al*., 2008). Kha *et al*. (2011) reported that pre-treatments prior to drying are one of the most important factor that affect the final powder product quality in term of physicochemical properties produced in drying. Pre-treatment, such as blanching is a familiar thermal treatment generally used for a variety of vegetables before drying or freezing.

The main purpose of blanching treatment is to inactivate enzymes, which causes the off flavors and color changes of the product (González-Fésler *et al*., 2008). However, blanching is also responsible for the undesirable change, such as pigment modification, tissues softening and nutrient losses (González-Fésler *et al*., 2008; Ahrné *et al*., 2003). Besides that, soaking in the edible chemical solution is also another familiar method of pre-treatment. However, certain solution may have adverse effect on the product, for example metabisulfate causes allergenic effect to some consumers due to the presence of SO_2 (Aydin and Gocmen, 2015). Soaking in the calcium solution might give better quality to the final product, such as improvement in texture, color, prevention in microbiological growth and respiration rate (Alandes *et al*., 2009). However, some calcium will cause the bitterness or flavor different, such as calcium chloride (Luna-Guzmán and Barrett, 2000). In Malaysia, calcium hydroxide is commonly used for food preparation. Therefore, it may be used as an alternative to preserve the food quality in order to maintain the color and extend the shelf life.

During the drying process, the food may lose heat sensitive nutrients and color and changing the physical properties depending on drying condition, such as temperature and drying time (Henriques *et al*., 2012). The powder produced with different pre-treatment might affect the powder properties such as, moisture content, particle size, bulk density, tapped density, water activity and color (Prajapati *et al*., 2011). The presence of moisture content in a powder can also affect the powder density and its flowability (Tze *et al*., 2012).

Pumpkin flesh is widely used in food industry to

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produce the food product compared to skin and seed. There have several researches done on pumpkin flesh powder production and its application in bakery products (Kulkarni and Joshi, 2013; Norfezah *et al*., 2010; Das and Banerjee, 2015), but still there have limitations about the effect of pre-treatment prior to drying for ensuring better quality of pumpkin powder. Since, the pumpkin seed and skin are a rich source of nutrients (Norfezah *et al*., 2010), the producing of pumpkin skin and seed powder could be also an alternative food additive in different food formulations together with wheat flour. Thus, this is fundamental need to explore the effect of pre-treatments in order to ensure the better quality of pumpkin powder. Therefore, the aim of this study is to investigate the effect of pre-treatment on physical and color properties of different portions of pumpkin powders produced by air frying.

MATERIALS AND METHOD

Sample Preparation:

Ripe pumpkins (*Cucurbita maxima*) were obtained from Long Ei Plantation Sdn Bhd. The flesh was sliced (3.0cm x 1.5cm x 0.2cm) and the skin was cut into the shape of rectangular (2.0cm x 1.0cm). Finally, the seeds were washed and drained. Powders from 3 different pumpkin parts: skin, flesh and seed will be produced and analyzed.

Pretreatments:

Two typea of pretreatments were conducted on the pumpkin samples before drying: calcium impregnation and blanching. For blanching process, the samples were immersed in the distilled water (70˚C) (Kumar *et al*., 2001) for 1 minute and then dried with absorbent paper. For calcium impregnation, the samples were soaked in $Ca(OH)_2$ solution(1:7, v/v, 1 part of $Ca(OH)_2$: 7 part of water) for 25 minutes and then washed with tap water before being dried with absorbent paper.

Air frying drying:

The air fryer (Philips HD 9220/20, Japan) was used and the temperature was set at 80˚C with an average air flow of 5.11 m/s. The air velocity was measured by a Testo 425 Compact Thermal Anemometer (Germany) (±0.01 m/s) placed in the chamber. The duration of drying for the seed was 1 hour 15 minutes whereas for the flesh, skin and unpeeled sample, it was 2 hour 45 minutes. After drying, the dried products were grounded into powder and sieved by using laboratory standard steel sieve shaker (Minor Sieve Shaker, Endecotts, London, England) at the size of 250 µm (60 mesh) and 710 µm (24 mesh, for the seeds).

Analysis of powder properties:

The material properties including water activity, true density, particle size and color were determined by the method described in Ng *et al*. (2012) except moisture content, bulk and tapped densities. The moisture content was determined by oven drying at 105˚C for 24 hours (AOAC, 2005). Water activity meter (GDX Instrumention Scientifique, France) was used to measure the powder water activity. Bulk density and tapped density of powders were measured followed by Sahin-Nadeem *et al*. (2013) and Ozdikicierler *et al*. (2014). The value of bulk and tapped density were used to calculate Carr index (Carr, 1965). The particle size of the powder was measured using a particle size analyzer (Malvern Mastersizer 2000, Malvern Instrument Ltd, UK). The color of powder was determined by using a color reader (CR-10; Konica Minolta Sensing America's Ltd., Ramsey, NJ, USA).

Statistical analysis:

Statistical analyses were performed using SAS 9.1 (SAS Institute Inc, Cary, NC, USA) to evaluate the mean, standard deviation and significant difference (p <0.05) by analysis of variance (ANOVA) and Duncan's multiple range test. All the measurement was conducted in triplicate. The diagrams of average value were generated by using Microsoft excel version of 2010.

RESULTS AND DISCUSSION

Effect of pre-treatment on moisture content of different pumpkin portions before drying:

Figure 1 shows that the $Ca(OH)_2$ pre-treatment reduced the moisture content by 2.1-3.35%, while blanching pre-treatment increased the moisture content by 0.96-3.62% in all parts as compared to control sample (untreated pumpkin portion). The seed part showed the minimum moisture content by around 31.86% pre-treated with $Ca(OH)_2$, while flesh part showed the maximum one by around 93.05% pre-treated with blanching.

Reduction of the moisture content by the $Ca(OH)_2$ pre-treatment can be explained by the osmosis process that caused the tissue to shrink (González-Fésler *et al*., 2008) and consequently, reduced the moisture content of the sample by gaining the calcium from the soaking medium (Barrera *et al*., 2009). For the blanching pre-treatment, the heats from the blanching medium modify the tissue of the fruit. It resulted in rupture of the membrane by elimination of the membrane resistances as well as decreased the cell wall resistance towards water due to the damage of the cell wall in the cell (González-Fésler *et al*., 2008).

Effect of pre-treatment on moisture properties of pumpkin powder:

The effect of pre-treatments was significantly different ($p < 0.05$) for the moisture content and water activity of different parts of pumpkin powder (Table 1). The $Ca(OH)_2$ pre-treatment reduced the moisture content by around 0.06-0.51% and water activity by around 0.007-0.035 in pumpkin powder (all parts) as compared to control powder (untreated pumpkin portion powder)In contrast, blanching pre-treatment increased both of the moisture content (around 0.26-0.8) and water activity (around 0.008-0.077) in all portion of pumpkin powder, if compared with control powder. The result displays that the skin ($Ca(OH)_2$ treated) powder has had the minimum moisture content (around 5.51), while the flesh (blanched) powder showed the maximum moisture content (7.55%). However, flesh ($Ca(OH)_2$ treated) powder had the minimum water activity and seed (blanched) powder had the maximum one (Table 1). It could be explained that the seed powder has high oil content and it is not easy to absorb water, so more free water is available in the seed powder. All the powder results present that the water activity is below 0.6, indicating these are microbiologically safe (Quek *et al*., 2007).

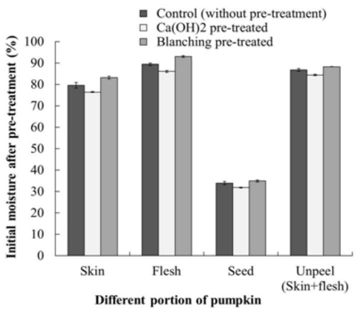

Fig. 1: Initial moisture content of different portion of pumpkin after the pre-treatment with $Ca(OH)_2$ and blanching.

Effect of pre-treatment on physical properties of pumpkin powder:

The result of physical properties of pumpkin powder under different types of pre-treatments shows that the pre-treatments are significantly different (p <0.05) for all parts of pumpkin powder except for unpeel powder (Table 2). The pre-treatment effect of $Ca(OH)_2$ and blanching on different portions of pumpkin powder showed significantly (p <0.05) different in particle size varied from 112.04 to 213.46 µm and 121.88 to 198.18 µm, respectively.

Table 1: Moisture properties of different portion of air-fried pumpkin powder pre-treated with $Ca(OH)_2$ and blanching.

Different portion of pumpkin	Moisture content based on pre-treatment (%)			Water activity based on pre-treatment		
	Control	$Ca(OH)_2$	Blanching	Control	$Ca(OH)_2$	Blanching
Skin	$5.78{\pm}0.02^B$	$5.51{\pm}0.04^C$	$6.04{\pm}0.06^A$	$0.373{\pm}0.003^A$	$0.338{\pm}0.006^B$	$0.382{\pm}0.028^A$
Flesh	$6.89{\pm}0.07^B$	$6.38{\pm}0.02^C$	$7.55{\pm}0.09^A$	$0.333{\pm}0.004^B$	$0.313{\pm}0.006^C$	$0.410{\pm}0.010^A$
Seed	$6.02{\pm}0.07^A$	$5.74{\pm}0.06^C$	$6.38{\pm}0.05^B$	$0.403{\pm}0.006^B$	$0.396{\pm}0.002^B$	$0.449{\pm}0.004^A$
Unpeel (Skin + Flesh)	$5.61{\pm}0.04^B$	$5.55{\pm}0.06^B$	$6.41{\pm}0.03^A$	$0.325{\pm}0.003^A$	$0.314{\pm}0.003^B$	$0.333{\pm}0.007^A$

Values are mean ± standard error, Superscript (A,B,C,…) = Treatment significant (p <0.05) in order to row, Control = Control without pretreatment, $Ca(OH)_2$ = Pre-treated with limewater, Blanching = Pre-treated with blanching

The reduction of powder particle size caused by $Ca(OH)_2$ pre-treatment could be reasoned to the shrinkage of tissues, which allows osmosis process to occur (the water flows from low concentration to high concentration). In contrary, Agar *et al*. (1999) also reported that calcium treatment can firm the sample. This can be further explained by the addition of the Ca^{2+} contributed to the stabilization of membrane systems and forming the Ca-pectates, which increased the rigidity of the middle lamella and cell wall. After that the drying process will reduce the moisture content in the sample and change the structure of the sample to be more crispy and brittle.

Blanching pre-treatment resulted in breakage of membranes and caused great damage in cell walls, which allowed moisture to flow into the tissue more easily (González-Fésler *et al*., 2008) thus, increasing the moisture content. However, the maximum range of particle size was found in seed part, while the minimum ranges of particle was observed both in flesh and unpeel parts.

The effect of pre-treatment was more effective to increase the bulk and tapped density in flesh, seed and unpeel powder than the control powder (untreated), while the densities reduced in skin powder. The pre-treatments were significantly different (p <0.05) on density properties and $Ca(OH)_2$ pre-treatment was more significant in increasing the bulk and tapped density in skin, flesh and unpeel powder except for seed. The skin powder showed the maximum densities in pre-treated powders. This could be attributed to the lower moisture content of skin powder.

Table 2: Physical properties of different portion of air-fried pumpkin powder pre-treated with $Ca(OH)_2$ and blanching.

Different portion of pumpkin		Effect of pre-treatments		
		Control	$Ca(OH)_2$	Blanching
Skin	Bulk density (kg/m^3)	518.68±15.16^A	505.51±7.44^A	473.41±6.34^B
	Tapped density (kg/m^3)	761.41±16.62^A	675.98±13.48^B	646.86±20.99^C
	Particle size (µm)	121.21±0.44^C	122.98±1.03^B	134.89±0.26^A
	Carr Index	31.84±3.03^A	25.19±2.22^C	26.74±3.24^B
Flesh	Bulk density(kg/m^3)	326.75±11.96^C	400.83±0.06^A	358.09±12.73^B
	Tapped density (kg/m^3)	395.30±8.79^C	518.61±15.30^A	448.79±11.36^B
	Particle size (µm)	135.11±0.49^A	118.10±0.19^C	121.88±0.33^B
	Carr Index	17.36±1.20^B	22.67±2.30^A	20.22±1.51^{BA}
Seed	Bulk density(kg/m^3)	304.80±2.70^B	375.75±8.34^A	385.18±14.85^A
	Tapped density (kg/m^3)	476.71±11.33^C	567.41±18.83^B	618.98±10.88^A
	Particle size (µm)	256.45±2.26^A	213.46±3.07^B	198.18±2.61^C
	Carr Index	36.04±1.61^A	33.71±3.15^A	37.73±3.42^A
Unpeel (Skin + Flesh)	Bulk density(kg/m^3)	390.03±8.86^B	423.44±10.48^A	392.40±7.69^B
	Tapped density (kg/m^3)	484.48±13.72^B	527.23±0.02^A	492.24±13.69^B
	Particle size (µm)	129.54±2.59^A	112.04±1.06^B	127.89±1.31^A
	Carr Index	19.49±0.44^A	19.68±1.98^A	20.27±1.19^A

Values are mean ± standard error, Superscript (A,B,C,…) = Treatment significant (p <0.05) in order to row, Control = Control without pretreatment, $Ca(OH)_2$ = Pre-treated with limewater, Blanching = Pre-treated with blanching

The reduction in bulk density was due to the presence of inter particle liquid bridges, which makes the particle further apart and produce a more open structure. The increase in mass due to increased moisture is lower than the subsequent volumetric expansion of the bulk. The higher the humidity, the more particles are combined into larger clusters. This results in leaving open spaces between them, which in turn lowers the bulk density (Goula, 2005). The particle size and its compact arrangement reduces the void spaces of skin powder might also be another reason to increase the bulk density (Tze *et al*., 2012).

Carr Index is a measurement of flow property correlated with bulk and tapped density. The CI value was significantly (p <0.05) indifferent in different portions of pumpkin powder except for skin, in which the pre-treatment caused the flowability of skin powder to be better by decreasing the CI around 5.1-6.65 in pre-treated powder as compared to untreated powder. In case of flesh powder, the CI increased by 5.31 in $Ca(OH)_2$ pre-treated flesh powder and by 2.86 in blanched flesh powder. Table 2 shows that the CI range of different parts of pumpkin powder (17.36-36.04) indicates that the powder flowability is in fair to poor range, in which unpeel powder is fair, flesh powder is passable and skin and seed is poor (Lebrun *et al*., 2012).

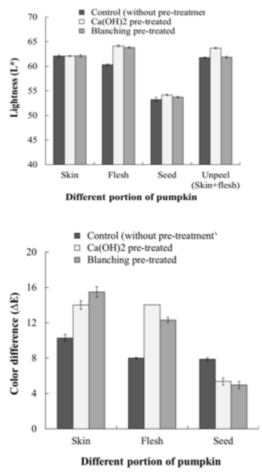

Fig. 2: Color properties of different portion of pumpkin powder during air frying pre-treated with $Ca(OH)_2$ and blanching: (a) Lightness and (b) Color difference.

Effect of pretreatment on color properties of pumpkin powder:

Figure 2(a) shows that the Lightness (L*) increased with the pre-treatment. For the $Ca(OH)_2$ treated powder, the samples showed the highest L* value (54.17-64.10) followed by the blanched treated powder (53.73-63.80) and control samples (53.23-62.07). This can be explained by Manganaris *et al*. (2005) that the sample treated with calcium can prevent the surface browning and it will maintain the color of the sample. Calcium treatment will reduce browning by stabilizing the Ca^{2+} ions in cell membranes (Poovaiah, 1986). According to Hopfinger *et al*. (1984) browning can occur in the fruit; this can be due to the loss of the Ca^{2+} ions in the fruit cell. Similarly, the Lightness (L*) increase in blanching as compared to control powder may be due to the blanching process, which is able to stop the color changes resulted from enzymatic reaction (González-Fésler *et al*., 2008) in fruits and vegetables.

Figure 2 (b) represents the effect of pre-treatment on total change of different pumpkin portion of pumpkin powder. Different pre-treatment can cause different degree of color change in powder product. The $Ca(OH)_2$ treated powder showed that the total change of color value is between 5.37-14.04, while blanching pre-treated powder showed that the total change of color of around 4.95-15.49. However, the skin powder with blanching pre-treated showed the highest total color change (15.49), while the lowest color change observed in blanched seed powder (4.95).

Conclusion:

The pre-treatments were significantly (p <0.05) different on different portion of pumpkin powder properties in general. The $Ca(OH)_2$ pre-treatment was observed in moisture reduction in all portion of pumpkin before drying and pumpkin powder after drying as compared to control sample/control powder, while the blanched pre-treatment was responsible to increase the moisture content in all portion of pumpkin/pumpkin powder both in before/after drying as compared to control sample/control powder. The powder produced pre-treated by $Ca(OH)_2$ had low final moisture content (5.51-6.38%), low water activity (0.313-0.396), small particle size (112.04-213.46 µm), high bulk density (505.51-375.75 kg/m^3), compare to the all portion of the blanched pumpkin powder and all portion of the control pumpkin powder. In contrary, pretreatment increased the lightness and color difference in pumpkin powder compared to control powder. Therefore, further investigation is required to analyze some chemical compounds of the final products related to pigment loss in order to explore the scientific fact.

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