QUALITY EVALUATION OF PUMPKIN (*CUCURBITA PEPO*) POWDER PRODUCED USING THREE DIFFERENT DRYING METHODS

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Abstract
Pumpkins are sweet and rich in β-Carotene. They are valuable sources of functional components but underutilised despite having potential as industrial crop. Poor postharvest handling contributed to wastage during bumper. Value-added products with appreciable keeping quality could be produced from pumpkin. Pumpkins were cleaned, cut and peeled. The seeds were scrapped off and flesh cut into uniform sizes. Samples were blanched in hot water at 95°C for 1 minute, drained and cooled to room temperature. They were then dried using three different methods. The samples were ground using laboratory mill and sieved using 125-micron mesh and evaluated for proximate composition, functional properties, microbial and sensory qualities. Proximate analysis results showed relatively low moisture content across all methods. The moisture content of samples ranged from 4.690±0.410 to 85.42±1.66 with cabinet dryer having the least moisture. Cabinet dried sample had the highest protein, crude fibre, ash and β carotene compared to others. The results indicated that increase in drying temperature are accompanied by decreases in water solubility, water and oil absorption capacities of the samples. Tent and sun-dried samples had better functional properties. Results of microbial analyses revealed low bacterial and fungal counts with fresh and cabinet dried samples recording no fungal growth. Results of sensory evaluation of pumpkin soup prepared with fresh sample as control revealed cabinet dried sample had good sensory quality in terms of colour, taste, flavour and acceptability. Quality pumpkin powder with good sensory qualities that could be utilised for culinary purposes could be produced using cabinet dryer.

Keywords: pumpkin, drying, powder, fruit, pulp

Received: 29.04.2020 Reviewed: 13.07.2020 Accepted: 24.07.2020

1. INTRODUCTION

Pumpkin belongs to the family *Cucurbitaceae* and is a widely grown vegetable all over the world. The origin of pumpkin has been attributed to Guatemala, Central Mexico or Columbia (Anon, 2008c). It is characterized by climbing herbaceous vines with tendrils and large fleshy fruits containing numerous seeds. Pumpkin has great economic potential as a food and as an industrial crop (Acquaah, 2004). It is a valuable source of functional components mainly carotenoids, lutein, zeaxanthin, vitamin E, ascorbic acid, phytosterols, selenium, and linoleic acid, which act as antioxidants in human nutrition. Pumpkin fruits are sweet when fully mature with yellow or orange flesh rich in β-Carotene, one of the plant carotenoids converted to vitamin A in the body. Pumpkin has health enhancing properties (Chweya and Eyzaguirre, 1999; Mnzava and Mbewe, 1997) because it has an abundance of macro and micro-nutrients, as well as antioxidants that boost the human body immunity against cancer and other deadly diseases (Oloyede *et al.,* 2013). Pumpkin has such nutritional potential unequalled to any other single crop (Encyclopedia of Foods, 2004) but despite this, it remains underutilized and less regarded by many households.

Poor postharvest handling and storage has contributed to wastage of pumpkins especially during bumper harvests. The development of value-added products from pumpkin and pumpkin seeds have been recommended as a way of increasing the utilization of pumpkin in the tropics (Giami and Bekebain, 1992; Giami and Isichei, 1999). Production of pumpkin powder will create a shelf stable product that has an appreciable keeping quality. This work is aimed at evaluating the quality of Pumpkin powders produced using different drying methods. This will in turn enable large scale processing of pumpkins during bumper harvests to reduce the postharvest loss and wastage.

2. MATERIALS AND METHODS

Fresh pumpkin (*Cucurbita pepo* 'Yar zaria) was obtained at *'Yan kaba* vegetables market (in Kano, Nigeria) and transported to the Food processing laboratory, Kano University of Science and Technology where it undergoes preliminary processing before drying. Sound fruits free of damages and blemishes were selected, cleaned, cut and seeds scraped. The fruits were then peeled and cut into uniform strips of 2.54 cm. The strips were then cut into uniform slabs with a thickness of 5 mm, a length 40 mm and a width of 20 mm as reported by Workneh *et al*. (2012). Thereafter, 300 g of the pumpkin slices was weighed and blanched in hot water at 95°C for 1 minute. The samples were then cooled to room temperature and then subjected to drying using the different drying methods. The drying process was monitored and samples weighed sat 3 hours interval until constant weight was achieved. The drying methods are open sun drying OSD, Tent drying TND (Model 2019: locally fabricated by NSPRI) and cabinet drying CBD (Model 1920: fabricated by NSPRI) with control samples of fresh fruits preserved by freezing slices from the same batch of sliced fruits. Before freezing the control, it was wrapped in aluminium foil then put in brown paper bags to protect them from light. Dried pumpkin fruit slices were ground using heavy duty blender, then sieved to a fine powder.

The resultant powder was then analysed for proximate composition, β carotene, functional properties as well as microbiological quality. Moisture, protein, fat, ash, crude fibre and carbohydrate were all determined according to AOAC (2010) while β carotene was determined according to Onwuka (2005). Water absorption capacity of the powder was determined using the method described by Sosulki *et al.* (1976). The method of Abbey and Ibeh (1988) was adopted oil absorption capacity of the sample. Bulk density was determined by the method of Narayana and Narasing-Rao (1984) and water solubility was determined by the method of Kha *et al.* (2010) with slight modifications.

3. RESULTS AND DISCUSSION

Table 1: has means of nutritive value of pumpkin fruit subjected to the different drying methods. There were significant differences between β-carotene, protein, ash, fibre, fat, and carbohydrate levels in the four treatments. Moisture content contributes a lot to the food safety and shelf-life. The present study found that moisture content of tent and sun-dried pumpkin fruit powder was higher. Sun drying retains the highest moisture level in pumpkin fruit. Cabinet drying is slower but able to achieve complete drying. Sun drying retains more moisture content which will render the flour going bad sooner.

Table 1: Means and standard deviation of nutrient content of pumpkin flour from three drying methods.

Composition	fresh sample	cabinet drying	tent drying	open sun drying
β-carotene(μg/g)	956.50 ± 77.50^{d}	8178.80 ± 122.70^{a}	3106.10 ± 122.9^{b}	1830.7 ± 71.6^{c}
Moisture (%)	85.42 ± 1.66^{a}	4.69 ± 0.41^{d}	10.30 ± 0.28^{c}	13.66 ± 0.18^{b}
Protein (%)	2.62 ± 0.62^{d}	14.88 ± 0.62^{a}	6.67 ± 0.16^{b}	4.93 ± 0.77^{c}
Fibre (%)	1.18 ± 0.18^{c}	3.65 ± 0.35^{a}	2.48 ± 0.11^{b}	1.58 ± 0.18^{c}
Fat (%)	0.80 ± 0.00^{d}	1.70 ± 0.07^{a}	1.38 ± 0.04^{b}	1.18 ± 0.11^{c}
Ash (%)	2.03 ± 0.04^{d}	4.64 ± 0.03^{a}	4.10 ± 0.11^{c}	4.39 ± 0.10^{b}
Carbohydrate (%)	7.73 ± 1.01^{c}	70.94 ± 0.73^{b}	75.34 ± 0.06^{a}	74.26 ± 0.98^{a}

Means followed by the same letter within the same row are not significantly different at P = 0.05

The low level of moisture content in cabinet dried pumpkin powder enables it to be preserved for longer period. A similar study comparing three drying methods on plantain, yam and cocoyam showed similar results where cabinet drying retained least moisture content (Agoreyo, *et al.*, 2011). Generally, removal of moisture, according to Morris *et al.*, leads to an increase in concentration of the nutrients (Morris *et al.*, 2004).

Protein content

Results showed that protein content in dried samples doubled 2-5 times in comparison with fresh sample. Higher values observed in dried pumpkin was due to drying which increased the dry matter and level of nutrients in any given weight. This is in agreement with the report of Morris *et al*. (2004) who concluded that removal of moisture may increase the nutrient content, which was the case in all the dried samples. Cabinet dried sample was higher than tent and sun-dried samples in protein. The protein content of the fresh fruit was similar to report of Fedha *et al.* (2010) which reported 4% protein.

Ash content

Ash content indicates the availability of mineral content of food substances Onwuka *et al.* (2002). Results of ash content ranged from 2.03– 4.64 % as shown in Table 1. The results obtained were ($P \leq 0.05$) statistically significantly across the different drying methods. The higher ash content obtained in the cabinet dried samples was similar to that reported in other literatures (Ukegbu and Okereke, 2013) and Onwuka *et al.*, 2002).

Fibre content

Crude fibre content ranged from 1.18% – 3.65% and values were statistically ($p<0.05$) significant. The results obtained indicated that cabinet dried powder retained more fibre than tent dried and sun-dried powder. Fibre is useful for maintaining bulk, motility and increasing intestinal tract. It is also necessary for healthy condition, curing of nutritional disorders and food digestion (Uwaegbute, 1989).

Carbohydrate content

Carbohydrate content was higher for tent dried samples (75.34%) compared to sun dried (74.260%) and cabinet dried sample (70.935%). Kolawole *et al*. (2011) reported that the carbohydrate content of vegetables increases after drying. The low carbohydrate content of vegetables shows that they supply little or no energy when consumed except when supplemented with other foods (Rossello *et al.*, 2000).

β-carotene content

The results for total carotene content of fresh pumpkin and the resultant dried pumpkin powders are also shown in Table 1. Lower values observed in sun dried pumpkin fruit were most likely a result of the effect of sun rays on the carotenoids. Similar results were reported in a study by Kiremire *et al*. (2010) where cabinet drying exhibited better retention of β-carotene, followed by tent drying and open sun retained the least β-carotene. Sun drying involves exposure of a product to solar radiation without protection against the sun's UV rays, and photo-degradation of the carotene with the subsequent loss of vitamin A activity. Changes in carotenoids and other pigments which affect the attractive colour and nutritive value of the final products can also be caused by heat and oxidation during drying (Que *et al.*, 2008). Similarly, higher drying temperatures and longer drying times produce greater pigment losses (Fellows, 1988). The higher levels observed in cabinet dried samples could be due to the fact that the method did not involve sun rays.

Results in the present study are based on pumpkin fruit which was thinly peeled, dried and recorded between 1830.7, 3106.1 and 8178.8μg/g of β-carotene, which was an increase from 956.5μg/g in fresh fruit. A study by Onoja (2014) on pumpkin leaves of a different landrace showed a similar trend, where drying significantly increased β-carotene levels.

Bulk density

The different drying method used in this study (cabinet, tent and sun) significantly ($P \leq 0.05$) affected the bulk densities of the dried pumpkin powders, as shown in Table 2.

Table 2: Functional properties value of pumpkin powder

Treatment	Bulk density (%)	Water absorption Capacity (g/g)	Oil absorption Capacity (g/g)	Water solubity (g/g)
CBD	0.43±0.06[a]	3.28±2.93[c]	3.03±1.79[c]	2.90±1.41[c]
TBD	0.51±0.01[a]	8.29±0.10[a]	8.59±1.46[a]	11.59±6.35[a]
OSD	0.56±0.05[a]	6.38±1.23[b]	5.97±0.71[b]	6.90±1.46[b]

Means followed by the same letter within a column are not significantly different at P = 0.05. CBD =cabinet dried powder, TND =tent dried powder and OSD = open sun dried powder.

The bulk densities of the dried pumpkin powders ranged from 0.5625, 0.51100 and 0.43 g/mL, depending on the drying method.
The bulk density provides an indication of the packing and arrangement of the particles, as well as the compaction profile of a material (Mirhosseini and Amid, 2013). Flours with low bulk densities require less dense packing materials (Akubor and Ike, 2012). The porosity and bulk density in foods depends on the initial moisture content, the composition, and the size (thickness and diameter) of the material and it is affected by the type of drying and the drying conditions (that is, temperature, air velocity and air humidity), particularly in air-drying (Marousis and Saravacos, 1990). In particular, dried pumpkin powders produced at higher temperatures exhibited slightly higher bulk densities than those produced at lower temperatures. Previous studies reported variations showing bulk densities of about 0.11 g/ml for freeze dried pumpkin puree powder (Dirim and Caliskan, 2012), 0.33 g/ml for freeze dried pumpkin powder (Que *et al*., 2008), and 0.402g/ml for kiwi fruit puree powder (Benlloch-Tinoco *et al*., 2012).

Water absorption capacity

As shown in Table 2, the water adsorption values for dried pumpkin powders produced by tent and sun were higher (8.29 g water/g, 6.38 g water/g respectively) than that for dried pumpkin powder produced by cabinet (3.28 g water/g). It was observed that the trend of reduction of water adsorption paralleled that of the increase in drying temperatures. As seen in previous studies, pumpkin flours prepared by hot-air drying at 70°C and freeze drying at -50°C showed water absorption values of about 2.74 and 2.60 g water/g in dry pumpkin flour, respectively (Que *et al*., 2008). The same value for coarse powder dried at 70°C in hot-air-drying oven at about 3.07 g water/g was seen in dry coarse powder (Zhang *et al*., 2009).

Oil absorption capacity

The oil absorption capacities of dried pumpkin powders are inversely proportional to the drying temperatures as shown in Table 2. The oil absorption capacities of the dried pumpkin powders were found to be 3.03g oil/g, 8.60g oil/g 5.97g oil/g for cabinet, tent and open sun drying respectively. These values were higher than the 2.38 g oil/g previously reported for freeze-dried pumpkin flour and 1.08 g oil/g for hot-air-dried pumpkin powder (Que *et al.*, 2008). Pumpkin powders have been observed to have high water and oil holding capacities, which could be an alternative emulsifying agent to be used in food formulations (Noor Aziah and Komathi, 2009). Accordingly, pumpkin powders with high water solubilities (at least 50%) are preferable (Noor Aziah and Komathi, 2009).

Water solubility

Many factors affect the water solubility of powdered products, including processing conditions, composition, particle size, density, pH and storage conditions (Mirhosseini and Amid, 2013).
It has been found that increase in drying temperature are accompanied by increased protein denaturation, which decreases the water solubility of the powder (Fellows, 1988). It has also been found that hot air drying reduced the oil and water absorption capacities and porosities of pumpkin powders, while it markedly increased their water solubility and bulk density (Que *et al.*, 2008). The result of this study showed that increased drying temperatures are accompanied by decrease in the water solubility, water adsorption capacity,

and oil adsorption capacity of pumpkin powders. Dried pumpkin powders produced by tent drying and sun drying showed water solubilities of more than 50% and high water and oil adsorption capacities. According to these results, dried pumpkin powders produced by tent drying and open sun drying may have more potential for baking purposes than those produced by cabinet drying. Higher water solubility was observed in tent dried pumpkin powder when compared with open sun powder is indicating that more starch had been decomposed during drying. This is due to the fact that water solubility reflects the extent of starch degradation in powders (Diosady *et al.,* 1985).

Results of sensory evaluation of pumpkin Powder

Pumpkin soup was prepared according to Cookie and Kate (2010) with some modifications. The soup was administered to a semi trained panellist which comprises of the students of the Faculty of Agriculture to evaluate the sensory qualities (colour, appearance, flavour, texture, taste and overall acceptability) on a 9-point hedonic scale. Sensory scores as assigned by the panel members for individual sensory attributes and overall acceptability were statistically analysed and are presented in Table 3.

Colour

The mean score for colour varied from 5.37 to 8.82. It was observed that the pumpkin soup prepared with cabinet dried powder had the highest score of 8.82 and high over the control.

Taste

The mean score for taste varied from 4.91 to 8.00 across the different drying method. It was observed that pumpkin soup prepared from cabinet dried powder scored the maximum (8.00) and high over the control. It is evident from the score that cabinet dryer retains and maintain the taste after drying.

Flavour

The mean score for flavour ranged between 4.82 and 8.55 with respect to different drying method. It was observed that pumpkin soup prepared with cabinet dried powder scored the maximum score of 8.55 and high over the control. It is an evident from the data that Pumpkin powder produce by cabinet drier produce a distinct flavour when cooking, and was much accepted with flavour point of view in pumpkin soup.

Texture

The mean score for texture varied from 6.73 to 8.64. The sensory scores for texture increase gradually with decrease in drying temperature. Increase in drying temperature reduced the liking of the product gradually from texture point of view. It is also observed that the soup thickness increased with decrease in drying temperature.

Table 3: Mean and standard deviation of sensory score for pumpkin soup prepared with pumpkin powder

Treatment	Colour	Taste	Flavour	Texture acceptability	Overall
Fresh	6.91 ± 1.14^{a}	7.46 ± 0.82^{a}	7.46 ± 0.82^{a}	6.73 ± 1.01^{a}	7.27 ± 0.65^{a}
CBD	8.82 ± 0.41^{a}	8.00 ± 0.78^{bc}	8.55 ± 0.52^{ab}	6.73 ± 0.91^{d}	7.73 ± 0.79^{c}
TND	7.18 ± 0.98^{b}	6.82 ± 0.75^{b}	6.91 ± 0.9	8.64 ± 0.51^{a}	7.18 ± 1.33^{b}
OSD	5.36 ± 0.81^{b}	4.91 ± 0.70^{b}	4.82 ± 0.87^{b}	8.09 ± 1.14^{a}	5.55 ± 1.04^{b}

Table 4: Mean and standard deviation on microbial and fungal count.

Samples	Bacterial count (cfu/g)	Fungal count (cfu/g)
Fresh sample	$3.0 \times 10^{2} \pm 1.41^{ab}$	NG
CBD	$1.15 \times 10^{2} \pm 0.21^{b}$	NG
TND	$3.00 \times 10^{2} \pm 1.41^{ab}$	$1.50 \times 10^{2} \pm 0.707^{ab}$
OSD	$5.50 \times 10^{2} \pm 0.71^{a}$	$2.00 \times 10^{2} \pm 1.41^{ab}$

Means followed by the same letter within a column are not significantly different at P = 0.05. CBD=cabinet dried powder, TND = tent dried powder and OSD = open sun dried powder, NG = no growth.

Overall acceptability

The mean score for overall acceptability ranged from 5.55 to 7.73. The results showed that pumpkin soup prepared by cabinet dried powder had a significant difference (at 5% level of significance) on appearance, taste, flavour, colour, texture and overall acceptability of the soup.

Results of microbial analysis

Table 4 presents the results of microbial analyses of the dried and the fresh samples. Fungal counts for the samples ranged from $1.5 x 10^2 \pm 0.707$ to $2.0 x 10^2 \pm 1.41$ CFU g^{-1}, while total viable counts ranged from $5.5 x 10^2 \pm 0.707$ to $1.15 x 10^2 \pm 0.212$ CFU g^{-1}. Open sun-dried sample recorded the highest fungal counts of $2.0 \text{ x } 10^2 \pm 1.41$ CFU g^{-1} and it also had the highest total bacterial counts of $5.5 x 10^2 \pm 0.707$ CFU g^{-1}. Absence of fungi and least number of bacteria in cabinet dried powder may signify good hygienic and handling practices. Generally, this is an indication of minimum adherence to Good Health Practices (GHP) and Good Manufacturing Practices (GMP) applied to cabinet dried powder as stipulated by the Joint FAO/WHO Codex Alimentarius Commission (1994). This study also showed that bacterial species were more in number than fungal species. This is in line with the findings of Karim and Wee (1996) who reported that fungal species are usually less in vegetables than bacteria because vegetables are generally less acidic and this favour the growth of bacteria. It is also established that bacteria grow faster than fungi even in conditions that favour both.

4. CONCLUSION

The results of this study have shown that cabinet drying was a better processing method compared to tent and open sun-drying in terms of proximate composition, microbial and sensory qualities. It can therefore be used successfully to develop products with enhanced nutrients which could find variety of food applications as functional and therapeutic food products thereby increasing the utilisation of pumpkin thus reducing the postharvest losses.

RECOMMENDATIONS

It is recommended that further studies be undertaken to establish the stability of these products on storage under different conditions and also determine the product shelf life. It is also recommended that further work be done on the optimum conditions with regard to temperature, time and air circulation in the cabinet dryer with the aim of improving the functional properties of the powder such as solubility, water and oil absorption capacities.

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