EFFECT OF OVEN AND FREEZE DRYING ON NUTRITIONAL COMPOSITION OF PUMPKIN (*Cucurbita maxima*) PROCESSED FLOUR

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Abstract

Pumpkin is very perishable and drying is one of methods to preserve it. The objective of the present study was to evaluate the effect of oven and freeze-drying methods on the nutritional composition of processed pumpkin flours. Pumpkin fruit samples (A, B, C, D and E) of *Cucurbita maxima* species were collected from local markets within the country. They were oven dried at 65°C for 8 hours and freeze dried at 30°C for 4 days, and then processed into flours. The moisture content, total ash, crude protein and total carotenoids were analyzed in both fresh samples and processed flours according to AOAC approved methods. Data obtained from laboratory analysis were subjected to analysis of variance (ANOVA) at significant differences ($P < 0.05$) between the nutritional contents of fresh samples, and of flours processed by oven and freeze drying. The study revealed that mean values for moisture, total ash and crude protein contents were 85.33, 7.62 and 12.78% for fresh pumpkin respectively; flour obtained by freeze drying contained 3.21, 6.25, and 9.35% respectively while by oven drying it was 1.19, 1.81, and 2.36% respectively. For total carotenoids, values were 180.13, 164.92 and 143.43µg / g-1 respectively for fresh pumpkin, flour made by freeze drying, and flour made by oven drying methods. Generally, the nutritional contents of fresh sample, flour made by freeze drying and flour obtained by oven drying methods were significantly different ($P < 0.05$). For the purposes of high yields of pumpkins flour, freeze drying could be the method of choice as it was found to give better results in terms of nutrients retention. The shelf life of the two flour batches should be studied in further research works.

Key words: Pumpkin, Pumpkin flour, oven drying, freeze drying, nutritional value

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Introduction

Pumpkins (*Cucurbita* sp) are believed to have originated in America(Stuart, 2004). Pumpkins give fleshy and squash fruit containing numerous seeds, most commonly orange in color when ripen (Pinho *et al*., 2011). It has been used traditionally both as human and animal feed as a vegetable or as an ingredient in various food dishes (Guiné and Barroca, 2012). Pumpkin is a nutritious fruit with good source of beta carotene, flavonoid poly-phenolic antioxidants such as lutein, xanthin, water soluble vitamins, minerals and proteins. It is important for body protection, prevention, growth, eyes sight and mental development for human (Raquel and Guiné, 2011). Like most vegetables, pumpkins are perishable food whose characteristics are changed with time (Henriques, 2012). For preservation and long-life storage, pumpkin is frozen or dried (Pinho, 2012) for storage or processing in flour. Pumpkin flour is used to supplement cereal flours in bakery products like cakes, cookies, bread, for soups, sauces, instant noodle and spice as well as a natural coloring agent in pasta and flour mixes (Bhat, 2013).

There exist several different drying methods used in the drying of fruits and vegetables. The most important drying methods include sun, oven, spray, freeze, microwave and vacuum drying (Ukegbu and Okereke, 2013; Alibas, 2012; Dirim and Caliskan, 2012; Henriques, 2012; Paul, 2011; Brennand, 1994). Each drying method has its own disadvantages and advantages concerning the aspects of socio-economy, technology and final product characteristics (Antal, 2015; Bronlund, 2015; Dirim and Caliskan, 2012; Rakcejeva *et al*., 2011; Que *et al*., 2008; Arévalo-Pinedo and Murr, 2006*)*. The objective of this study, with focus on qualitative characteristics of pumpkin processed flour, was to assess the effect of freeze and oven drying methods on total carotenoids, ash, and crude protein and moisture contents.

Materials and Methods

Pumpkin (*Cucurbita maxima*)

The present study focused on pumpkins cultivated in Rwanda. Five samples of *Cucurbita maxima*, the very productive species, were randomly collected from five different local markets in Rwanda. During sampling, the whole pumpkin fruit was picked. Each sample was transported, in polyester bag, at ambient temperature conditions, to laboratory for analysis and processing. The fruits were chosen considering skin and weight features. The skin was hard for all fruits, and the fruits were dense and of different weight varying from 1.7 kg to 11 kg. Collected samples were indexed A, B, C, D and E corresponding to 1.7kg, 2 kg, 2.7kg, 2.8kg, and 11 kg respectively. Each raw pumpkin fruit were washed with potable water, peeled, diced (10cm), de-seed, diced (2cm size) and mixed to have a homogenous mass. The mixture was used for chemical analysis and processing.

Flour Processing: To process pumpkin flour, the drying process was done by employing two drying methods, namely freeze drying and oven drying. Before drying, each sample was blanched in water at 95^{o} C for 1min as described by Paul (2011) and then grated using stainless steel grater. After drying, each sample was ground in mortar and sifted through a flour sieve (0.5mm) to obtain flour for analysis (Fig.1). **Freeze Drying:** One hundred grams of each chopped sample was put in plastic cup, frozen at -18^{o} C for 3 hours and then freeze dried under vacuum (2mbar) at - 30 °C for 4 days, using TYOTRAP freeze dryer. **Oven Drying:** Each grated sample was transferred to stainless steel

plate and dried in an oven dryer (Fan Convection Oven, number 08G030, at 65°c for 8hours.

Chemical Analysis

The fresh pumpkin pulp and pumpkin flour were analyzed in triplicate for moisture, total ash, crude protein and total carotenoids content. Moisture content was determined by AOAC method 930-04 (AOAC, 1995). Total ash content was analyzed as total inorganic matter by incineration of a sample at 550°C as described by AOAC (1995). Crude protein content was analyzed as described by official micro Kjeldahl method (AOAC, 1995) while total carotenoids were determined using a colorimeter method as described by De Carvalho *et al.* (2012).

Statistical analysis

Using R-studio software, version 3.6.1, all data were analyzed and reported as mean ± standard error. The comparison of obtained data of five samples was done for each drying method (intra-comparison) and between two drying methods (inter-comparison) by using one-way analysis of variance (ANOVA) with the significant difference at P value less than 0.05 ($P < 0.05$).

Results and discussion

Moisture content: The moisture content results of the fresh fruits and processed flour are presented in Table 1.

Table1. Moisture content of fresh and dried pumpkin by oven and freeze drying (in %)

Samples	Fresh pumpkin fruits	Oven dried flour	Freeze dried flour
A	89.77 ± 0.25^{ad}	8.37 ± 0.74^{bd}	15.73 ± 0.70^{cd}
B	83.10 ± 0.36^{ad}	8.80 ± 0.46^{bd}	12.10 ± 0.46^{cd}
C	86.50 ± 0.66^{ad}	9.20 ± 0.47^{bd}	13.03 ± 0.25^{cd}
D	85.33 ± 0.85^{ad}	6.19 ± 0.21^{bd}	10.57 ± 0.81^{cd}
E	81.97 ± 0.95^{ad}	5.56 ± 0.53^{bd}	12.50 ± 0.50^{cd}
Average	**85.33 ± 0.61^{d}**	**7.62 ± 0.48^{d}**	**12.78 ± 0.54^{d}**

Values are mean ±S.D; n=3; a, b, c, d: significant different

For fresh pumpkin fruits, results showed that all samples have high moisture content varying from 81.97% to 89.77%, where sample A had the highest moisture content (89.77%) while sample E had the lowest moisture contents of (81.97%). For the pumpkin flour, it was observed that sample C had the highest moisture content (9.2%) while E had the lowest moisture content (5.56%) in oven dried samples. Sample A had the highest moisture content (15.73%) and sample D had the lowest moisture contents (10.57%) among the freeze-dried samples. The significant difference ($P < 0.05$) was noted in data within each drying method, and between fresh pumpkin fruits.

Total ash content: As observed in Table 2, results of fresh pumpkin fruit samples are moderate, and varying between 0.99% - 7.69%, where samples A and E had the highest (7.69%) and the lowest (0.99%) levels of ash content, respectively.

Table 2. Total ash content of fresh and dried pumpkin by oven and freeze drying (%)

Samples	Fresh pumpkin fruits	Oven dried flour	Freeze dried flour
A	$7.69\pm0.69^{a,d,e}$	$9.33\pm0.64^{b,d}$	$13.13\pm0.48^{c,e}$
B	$2.27\pm0.32^{a,d,e}$	$5.73\pm0.41^{b,d}$	$7.58\pm0.20^{c,e}$
C	$2.98\pm0.20^{a,d,e}$	$6.10\pm0.19^{b,d}$	$7.33\pm0.20^{c,e}$
D	$2.14\pm0.41^{a,d,e}$	$5.41\pm0.22^{b,d}$	$10.29\pm0.20^{c,e}$
E	$0.99\pm0.26^{a,d,e}$	$4.70\pm0.46^{b,d}$	$8.45\pm0.54^{c,e}$
Average	**3.21±0.42**	**6.25±0.38**	9.35±0.32

Values are mean ±S.D; n=3 a, b, c, d, e: significant different

Results of pumpkin flour samples varied between 4.7% - 9.33% for the flour obtained through oven drying method with the highest and the lowest levels in sample A (9.33%) and sample E (4.7%), respectively, while for the flour obtained through freeze drying, samples A and C had higher (13.13%) and lower (7.33%) levels, respectively. In all samples, unprocessed and processed by the two methods, there was intra-variability and inter-variability of data with a significant difference ($P < 0.05$).

Crude protein: The obtained results of crude protein varied from 0.79% to 1.47% for fresh pumpkin fruits, where sample A had the highest level and sample B the lowest level of crude protein. In the same way, results varied from 1.19% to 2.93% for the flour obtained

through oven drying method, where sample A was found to have the highest content and sample B had the lowest content of crude protein. With freeze drying method, the results varied from 1.93% to 3.5% crude protein of the flour, where the highest level was found in sample A of 3.5 % and the lowest level (1.93%) in sample B. Crude protein did not show any significant difference with P value of 0.052 (P> 0.05) within samples of fresh pumpkin fruits, between oven drying method and freeze drying method, and among all the three batches of samples i.e. from fresh pumpkin fruits, freeze dried flour and oven dried flour (table 3).

Table 3. Crude protein of fresh and dried pumpkin by oven and freeze drying (%

Samples	Fresh pumpkin fruits	Oven dried flour	Freeze dried flour
A	1.44 ±0.24	2.93±0.25	3.55±0.45
B	0.79±0.03	1.19±0.24	1.93±0.17
C	1.27±0.09	1.76±0.05	2.20±0.13
D	1±0.03	1.65±0.13	1.95±0.17
E	1.47±0.07	1.55±0.21	2.20±0.32
Average	**1.19 ±0.09**	**1.81±0.17**	**2.36±0.24**

Values are mean ±S.D; n=3

Total carotenoids : The total carotenoids results, as detailed in Table 4, showed that in fresh pumpkin fruits, it varied from 108.50 µg.g–1 to 253.94 µg.g-1, while it was low in sample D and high in sample A, respectively.

Table4. Total carotenoids of fresh pumpkin and pumpkin flour obtained through oven and freeze-drying methods (µg.g-1)

Samples	Fresh pumpkin fruits	Oven dried flour	Freeze dried flour
A	253.94±0.61^{ad}	207.51±0.58^{bd}	235.68 ± 0.66^{cd}
B	236.42±0.45^{ad}	195.75± 0.80^{bd}	212.46 ±0.55^{cd}
C	185.31±0.89^{ad}	146.29± 1.10^{bd}	168.09± 0.86^{cd}
D	108.50±0.60^{ad}	79.22 ± 0.45^{bd}	98.70 ± 0.91^{cd}
E	116.48±0.68^{ad}	88.38 ± 1.35^{bd}	105.53 ± 0.56^{cd}
Average	**180.13 ±0.64**	**143.43± 0.85**	**164.92± 0.70**

Values are mean ±S.D; n=3 a, b, c, d: significant different

Total carotenoids in pumpkin flour obtained through oven drying method varied from 79.22 µg.g-1 to 207.51 µg.g-1 with lower level in sample D and higher level in sample A, respectively. In freeze dried pumpkin flour sample, the results showed that carotenoids varied from 98.70µg.g-1 to 235.68 µg.g-1, where sample D had lower and A the higher levels in total carotenoids.

DISCUSSION

The present study generated results for moisture, ash, crude protein and carotenoids contents of pumpkin species (*Cucurbita maxima*) in its different forms viz. fresh pumpkin fruits, freeze-dried pumpkin flour, and oven-

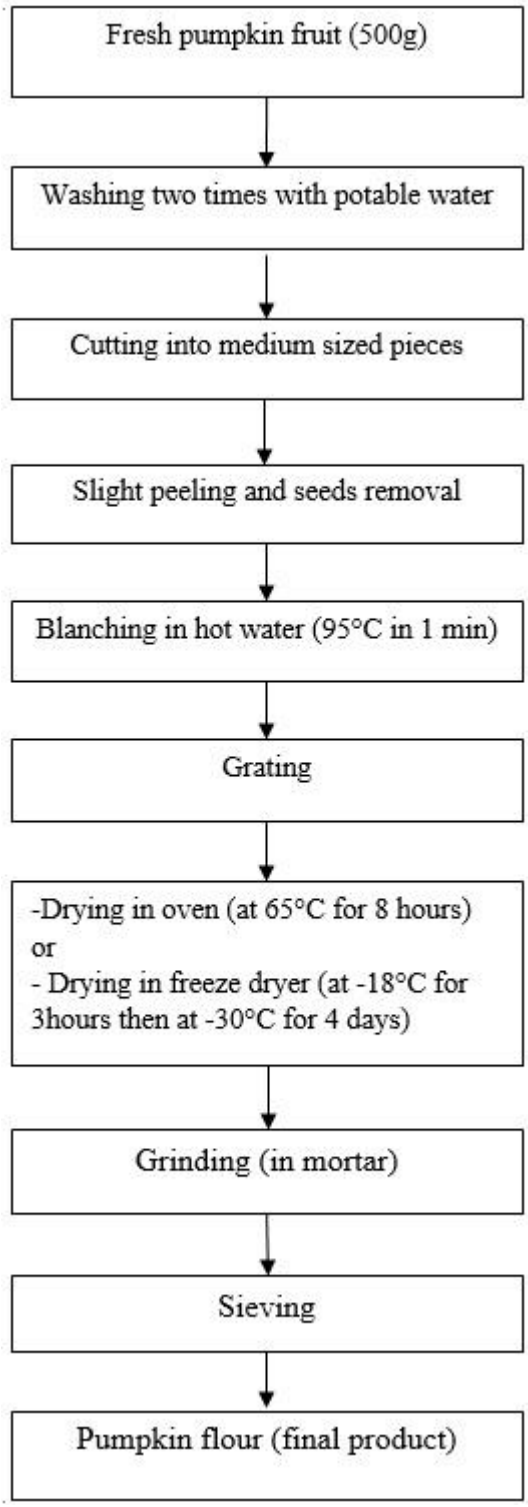

Figure 1. Pumpkin flour processing flow chart

Moisture content

The results of moisture content, with mean values varying from 81.9 to 89.77%, were not far from results obtained by other researchers. Henrique, (2012) obtained 90.81 g/100g in *C. maxima* pumpkin cultivars. Falade (2010) reported that fresh pumpkin had high moisture content (90% - 92%). The differences may be attributed to various factors, such as geographical region and growing conditions, maturity, size, storage time after harvesting and eventually the species variety. This fact may be explained through this study where sample A of green color was of big size, middle maturity with short storage time while sample E of white color was much mature with small size and zero storage time (from the farm). In all sample batches, moisture content in oven dried (5.56% to 9.2%) and freeze dried (10.57 % to 15.73 %) samples, were not significantly different to the findings (7% for oven and 11% for freeze drying) by Henrique *et al.* (2012), moisture content level of pumpkin flour was also significantly different for both oven and freeze drying methods, with P value of 0.001 ($p<0.05$). This may be due to the effect of different temperatures used during drying (Falade, 2010) since in the present study the oven drying was carried out at 65℃ for 8 hours while the freeze drying was done at -30°C for 4 days. These two drying methods were capable of removing 70-80% moisture content in the pumpkin fruits, where the oven drying method was found to have the higher drying capability in less process time.

Ash content: The ash content results (0.99-7.6 %) in fresh pumpkin were in the range with the recent past findings of 0.69 % to 12.34 % (Kulaitiene *et al.*, 2014; Bhat, 2013; Dirim and Caliskan, 2012; Henrique, 2012; Fedha, 2010). The mean values (7.33% -13.13%) for the ash content in the pumpkin freeze-dried flour and 4.7% to 9.33% in the pumpkin oven dried flour, were in the range of Pongjanta *et al.* (2006) findings. Both drying methods increased the ash content, but results were not significantly different with P-value of 0.36 ($P>0.05$). The increasing in ash content was reported in tropical food: *Colocasia esculent*a (Cocoyam), D*ioscorea rodunta* (White yam) and *Musa paradisiacal* (Plantain) (Agoreyo *et al.*,2011; Wijewardane, 2015), where they used various drying methods significantly increased the ash content. In the present study, the increase in ash content could be the result of the removal of moisture leading to increase the concentration of nutrients content (Wijewardane, 2015).

Crude protein

Mean value of crude protein (0.79% - 1.47 %) for the fresh pumpkin was similar (0.6% -1.6%) to the findings (1.3%) of Fennema *et al.* (2004) and Bhat (2013) in fresh pumpkin fruits. In pumpkin flours, the mean value ranges were 1.19% - 2.93%for oven dried and 1.93% - 3.55% for freeze dried flour. It was observed that results of the present study were close to the findings of Wijewardane *et al.* (2015) who reported 2.34% and 4.06 for oven and freeze-dried flour, respectively. The protein content of fresh pumpkins was enhanced by these two drying methods. The same conclusion was noted by Wijewardane *et al.* (2015). According to Agoreyo (2011), this increasing in protein content could be due to the reduction of moisture content leading to increase in the nutrient content and to extend keeping quality of the food. Moreover, the loss of moisture increases nutrient density of foods of which protein is one among them (Wijewardane *et al.,* 2015).

Total carotenoids

The obtained results in total carotenoids (108.50 $\mu g.g^{-1}$ - 253.94 $\mu g.g^{-1}$) of the raw pumpkins were similar to the findings (212 $\mu g.g^{-1}$ and 230 $\mu g.g^{-1}$) reported by Pacheco *et al.* (2014), while the findings of de Carvalho *et al.* (2012), for total carotenoids in landrace pumpkins ranged from 234.21 $\mu g.g^{-1}$ to 404.98 $\mu g.g^{-1}$ in two samples, the results which are slightly higher than this study, may be due to the analytical methods. The mean values of obtained results for total carotenoids (79.22 $\mu g.g^{-1}$- 207.51 $\mu g.g^{-1}$) in oven dried flour and (98.70 $\mu g.g^{-1}$- 235.68 $\mu g.g^{-1}$) in freeze dried flour were not far from the findings of other authors such as Bronlund (2016) (207.34 $\mu g.g^{-1}$ of total carotenoids in oven dried pumpkin flour). The oven and freeze-drying methods have negatively affected the concentration of total carotenoids, where their concentration in fresh pumpkins decreased with significant difference with P value $9.6*10^{-6}$ ($p<0.05$) between the two drying methods. According to Dirim and Caliskan (2012), the decrease in total carotenoids content can be attributed to degradation of β-carotene as well as other carotenoids. Generally, it is due to auto-oxidation, where the highly unsaturated chemical structure of carotenoids makes them very sensitive to thermal degradation and oxidation.

The present study was related to the effect of oven and freeze-drying methods on total carotenoids, crude protein, total ash and moisture content in the processed pumpkin flour. It was observed, based on p-values, that the freeze-drying method reduced less the total carotenoids than by the oven drying method. Two methods equally affected, both the ash and protein content. The oven drying was better than freeze. Those observations were the basis of the positive verification of the hypothesis on improvement by drying of pumpkin.

CONCLUSION

The present study, on effect of oven and freeze-drying methods on pumpkin flour content, focused on the *Cucurbita maxima*, the species known to be more productive and popular in Rwanda. The unprocessed pumpkin had high nutrients in all analyzed parameters, but the higher the moisture content the more perishable the fruit is, and hence processing becomes imperative for increased storability purposes. Moreover, two drying methods differently affected the nutritional composition of pumpkin whereby the freeze-drying method was found to be the better method of drying because it retained more minerals, protein and carotenoids. However, it is more time consuming and expensive.

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