Effect of Dehydration Methods on Chemical Properties and Antioxidants in Dehydrated Powdered Vegetables

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Abstract— *Vegetables possess essential dietary nutrients such as vitamins, minerals, fiber and essential antioxidants. Clinical research has revealed that consumption of vegetables and fruits are beneficial to age related diseases, cancers and heart diseases. Storage of fresh produce is the best way to maintain its nutritional value, but most storage techniques require low temperatures, which are difficult to maintain throughout the distribution chain of fresh produce. Present study was conducted to evaluate the effectiveness of various dehydration techniques; sun drying, solar drying, freezing & drying (Freeze one hour followed by mechanical drying at 55°C), vacuum drying and oven drying on chemical properties and antioxidants in different dehydrated powdered vegetable prepared from Pumpkin (Cucurbita maxima), Tampala (Amaranthuscaudatus), Sweet potato (Ipomoea batata) and Hibiscus (Hibiscus rosa-sinensis). Moisture content, total ash, crude fiber, fat, crude protein, total phenolic content and β - carotene were determined (n=3). The results were analysed by complete randomized design using ANOVA and mean separation was done by using Least Significant Difference (LSD) at α= 0.05. Vacuum dried pumpkin powder retained higher level of fat content (2.20 %). The value was significantly different from other treatments except solar drying. In pumpkin ash content (4.35%) was significantly different from all other treatments. Higher retention of β-Carotene and total phenolic content was recorded in vacuum dried samples significantly (α< 0.05). Sun drying and solar drying were significantly affected on reduction of retention of total phenols. Tampala (Amaranthus caudatus) and Hibiscus (Hibiscus rosa-sinensis) powders contain higher level of anthocyanin under vacuum drying. Ash and fiber content of oven dried samples were higher than the protein content. Therefore vacuum drying is recommended as the most effective drying method to protect chemical properties and retention of antioxidants in dehydrated vegetables.*

Keywords— Dehydration, Vegetables, Proximate Composition

I. INTRODUCTION

Vegetables are rich in essential dietary nutrients such as vitamins, minerals, fiber and essential antioxidants. Clinical research revealed that consumption of vegetables are beneficial to age related diseases, cancers and heart diseases. Antioxidants are chemical compounds that can bind with free oxygen radicals and prevent damaging the healthy cells, where as pro-antioxidant act indirectly either by modulation of direct agents or by regulation of the biosynthesis of antioxidant proteins. Plants may contain a wide variety of free radical scavenging molecules, such as polyphenols and carotenoids. These plant secondary metabolites are well recognized as natural antioxidants linked to reduction of development and progression of life-style related diseases.

Storage of fresh vegetables is the best way to maintain its nutritional value, but most storage techniques require low temperatures, which is difficult to maintain throughout the distribution chain. Drying is the suitable alternative for postharvest management especially in tropical countries such as Sri Lanka. In sufficient low temperature distribution system and handling facilities in Sri Lanka leads product contamination and deterioration. Therefore development of alternate drying technologies and methods are depends on various factors such as type of product, availability of drier, cost of dehydration and final quality of the product (Bezyma and Kutovoy 2005). Energy consumption and quality of dried products are other critical parameters in the selection of drying process. Therefore the objective of this study was to determine the influence of different drying methods to preserve antioxidants and other chemical properties of the selected vegetable powders.

II.MATERIALS AND METHODS

A. Sample preparation

Sweet potato (*Ipomoea batata),* Pumpking (*Cucurbita maxima),* Tampala (*Amaranthuscaudatus) and* Hibiscus (*Hibiscus rosa-sinensis)* were subjected to prepare dehydrated powder by different dehydration technique;

sun drying, solar drying, freezing & drying (Freeze one hour followed by mechanical drying (55°C), vacuum drying (50 °C) and drying using lab scale air oven, at 55°C. Sweet potato and pumpkin were pretreated by dipping in sodium meta-bisulfate solution (SMS), 1.5g of SMS/1 liter of water followed by blanching (3 min, hot water at 60°C). Tampala and hibiscus were washed and cut into pieces and steams blanched for 1 min. before drying. All vegetable powders were prepared by drying followed by grinding using a mixer grinder and sifted to yield fine partials (150 µm).

B. Determination of physicochemical quality parameters

Moisture content was determined using the method described in AOAC, 2005. Crude fat was determined with dried sample (5g). Fat was extracted using petroleum ether using Soxhlet extraction apparatus for 6 hrs. Extract ether was filtered in pre-weighed beakers, petroleum ether was evaporated completely and fat content was measured (AOAC 2005). Crude fiber and crude protein (micro-kjeldal method) were estimated (AOAC 2005). β -Carotene content was determined using UV spectrophotometer (UV 1601, shimadzu, Koyoto, Japan). The results expressed as mg/100g in dry weight. Total anthocyanin content (Ranganna, 1986), total phenolic content (TPC) of dehydrated food samples were determined according to the method described by Velioglu et al 1998 with some modifications. The result was expressed as mg of gallic acid equivalents per g of sample.

C. Statistical analysis

Data obtained were in triplicate (*n=3*) and the results were assessed by completely randomized design using ANOVA by SAS statistical package. Mean separation was done by using Least Significant Difference (LSD) at α= 0.05.

III. RESULTS AND DISCUSSION

The proximate analysis was conducted for the dehydrated powdered vegetable produced using different dehydration techniques are shown in Table 1. The moisture content of fresh samples were ranged from 73.42% to 89.34% and reduced up to 8.84, 4.31, 7.21 and 7.21% in pumpkin, sweet potato, hibiscus and tampala respectively. The fat content in pumpkin, sweet potato and tampala were ranged from 1.67- 2.2%, 0.48-1.27% and 0.41- 0.82% respectively. Significant amount of fat content was not detected in hibiscus. The higher fat content (2.7%) was recorded in pumpkin under vacuum drying. The protein content of dehydrated pumpkin, sweet potato, hibiscus and tampala were ranged from 0.55 - 4.06%, 0.16 - 1.17%, 3.49- 4.05% and 80.25- 23.52 respectively. The higher level of protein after dehydration was recorded by tampala under vacuum drying followed by pumpkin (4.06%). Reduction of moisture increases nutrient content and extends keeping quality of the food (Osagie and Onigbide, 1992). Oven dried vegetable powder samples showed higher level of ash and fiber content but less in protein. The higher fibers in dried vegetable samples were due to loss of moisture. In addition, it is known that loss of moisture increases nutrient density of foods of which fiber is among the nutrients. The results were within the values reported by Singh et al. 2006. Fruits, vegetables and their products in the dried forms are good source of energy, mineral and vitamins. However during the process of dehydration, there are changes in nutritional quality is occurred.

The β -Carotene content in dehydrated pumpkin was 38.7mg/100g by vacuum drying method (table 2) . This may be due to low temperature applied during drying process. The anthocyanin content was evaluated in hibiscus , tampala and peel of sweet potato. The values were ranged from 84.28- 107.5mg/100g, 80.37-215.19% and 1.11- 2.53mg/100g respectively. The higher concentration was recorded by tampala under vacuum drying followed by hibiscus (107.5mg /100) under same drying method. Retention of total phenolic content of pumpkin ranged from 0.11- 0.06 mg/GA/g and the maximum was recorded (0.06±0.03mgGA /g) in vacuum dried sample. There were values were significantly different (α< 0.05) from other treatments employed. The sun drying and solar drying were significantly affect for retention of phenols and it was recorded the lower retention compared to other treatments. Oguri et al., 2011 reported that, the fresh leeks had higher phenolic contents (116.43 mg rutin eq. 100 g) when compared to the dehydrated samples (26.33 mg rutin equivalent /100 g), which may be due to the breakdown of phenolics during dehydration. Meyer et al. (1998) stated that the antioxidant activities of phenolics in different vegetables markedly vary and that it may be due to the differences in the phenolic compound structures primarily related to their hydroxylation and methylation patterns.

Retention of total anthocyanin content was higher in vacuum dried hibiscus samples (107.5±0.45 mg/100g) and Thampala (215.19±0.53 mg/100g) respectively and the values were significantly difference from other treatments (α< 0.05). Retention of anthocyanin in all tested vegetables were s affected by oven drying and sun drying methods thus resulted lower retention values of anthocyanin after dehydration. Anthocyanin content of sweet potato powder (purple skin colour tubers) was 3.76±0.02 mg/100g; therefore sweet potato is not a good functional ingredient. The highest anthocyanin content (2.53±0.02 mg/100g) was recorded in vacuum dried samples and values were significantly difference (α< 0.05) from other treatments tested.

Table 1. Quality of freshly prepared vegetable powder by different drying techniques

Fruit	parameter	Solar drying	Oven drying	Freeze prior to drying	Sun drying	Vacuum drying
Pumpkin	Moisture (%)	9.41±0.01	9.74±0.02	8.84±0.04	11.41±0.01	12.24±0.06
	Fat (%)	2.1±0.06	1.67±0.10	1.98±0.10	1.76±0.05	2.20±0.10
	Protein (%)	0.58±0.58	2.34±0.05	4.06±0.05	0.55±0.04	2.92±0.02
	Total ash (%)	3.67±0.15	3.66±0.10	3.82±0.13	3.63±0.15	4.35±0.15
	Fiber(%)	8.50±0.10	10.30±0.87	9.50±0.20	8.50±0.10	8.88±0.05
S/ potato	Moisture (%)	4.64±0.03	4.70±0.02	4.31±0.01	5.91±0.05	5.61±0.03
	Fat (%)	0.65±0.02	0.48±0.10	1.27±0.10	0.58±0.09	0.58±0.02
	Protein (%)	1.17±0.01	0.58±0.01	0.17±0.01	0.17±0.01	0.16±0.02
	Total ash (%)	2.17±0.06	2.13±0.06	2.03±0.25	2.31±0.02	2.32±0.02
	Fiber (%)	2.69±0.18	2.36±0.20	1.75±0.03	1.77±0.01	1.71±0.01
	Anthocyanin (mg/100g)	1.44±0.03	2.46±0.07	2.22±0.02	1.11±0.06	2.53±0.02
Hibiscus	Moisture (%)	7.21±0.02	7.59±0.02	7.50±0.01	7.42±0.02	7.50±0.01
	Fat (%)	-	-	-	-	-
	Protein (%)	3.49±0.02	3.80±0.17	3.78±0.19	3.55±0.05	4.05±0.05
	Total ash (%)	4.11±0.01	4.41±0.02	4.11±0.01	4.31±0.01	4.11±0.01
	Fiber (%)	6.51±0.02	6.79±0.01	6.31±0.01	6.51±0.02	6.11±0.01
	Anthocyanin mg/100g	94.26±0.07	86±0.40	93.32±0.02	84.28±0.07	107.5±0.45
Tampala	Moisture (%)	15.43±0.02	7.84±0.02	7.60±0.05	15.29±0.03	7.21±0.02
	Fat (%)	0.81±0.01	0.61±0.01	0.41±0.01	0.81±0.01	0.82±0.01
	Protein (%)	10.83±0.01	8.25±0.02	20.43±0.15	9.66±0.05	23.52±0.47
	Total ash (%)	4.00±0.01	4.23±0.02	4.32±0.01	4.11±0.01	4.11±0.01
	Fiber (%)	10.19±0.02	10.65±0.03	9.98±0.01	10.80±0.01	10.39±0.02
	Anthocayanin mg/100g	108.88±0.10	80.31±0.07	209.64±0.05	91.66±0.05	215.19±0.53

Standard deviation for three replicate (*n*=3) determinations.

Table 2. $^{\beta}$-Carotene content (μg/100g) and Total phenolic content (TPC) (mg of gallic acid (GA)/1g) of dehydrated pumpkin by different dehydration methods

	Solar drying	Oven drying	Freeze prior to drying	Sun drying	Vacuum drying
$^{\beta}$ carotene (mg/100g)	20.23±0.01	29.1±0.02	32.6±0.04	18.4±0.01	38.7±0.02
(TPC) (mgGA /g)	0.01±0.01	0.02±0.11	0.02±0.02	0.01±0.02	0.06±0.03

Standard deviation for three replicate (*n*=3) determinations.

IV. CONCLUSIONS

Higher retention of antioxidants such as β–Carotene, anthocyanin and total phenolics were recorded in vacuum dried vegetable samples and values were it significantly difference from other treatments (α= 0.05). Maximum retention of anthocyanin content was recorded in powders prepared by Tampala (*Amaranthuscaudatus)* followed by Hibiscus (*Hibiscus rosa-sinensis).*The sun drying and solar drying were significantly affected for the retention of phenols. Lower retention was recorded compared to the other treatments. Vacuum dried pumpkin powder retained higher level of fat content (2.20%) that was significantly difference from other treatments except solar drying. The ash content in pumpkin (4.35%) was significantly difference from all other treatments. Among other vegetables, dehydrated powdered Tampala was contained higher protein content 23.52±0.47 %. Oven dried powdered vegetable samples showed higher level of ash and fiber content but less in protein. Therefore vacuum drying can be recommended as the most effective drying method to protect the chemical characteristics of different vegetable powders.

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