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Assessing the Effects of Drying on the Functional Properties and Protein Solubility of some Edible Tropical Leafy Vegetables

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Abstract

Green amaranth (Amaranthus hybridus), Scent leaf (Ocimum gratissimum), Basil leaf (Ocimum basilicum), Bitter leaf (Vernonia amygdalina) and Fluted pumpkin leaf (Telferia occidentalis) were subjected to sun-drying and freeze-drying. The pulverized samples were divided into two portions, first portion analysed for functional properties while protein solubility was determined on the second portion. The water absorption capacity, WAC in sun-dried leaves varied from 141.2±0.2% in A. hybridus to 162.1±0.1% in T. occidentalis. Foaming capacity and stability varied from 17.7; 1.0% in O. gratissimum; V. amydgalina to 96.8; 5.0% in A. hybridus and T. occidentalis respectively while the result on least gelation showed little or no variation in all samples. The freeze-dried samples had significantly higher (at $P<0.05$ level) foaming capacity and foaming stability but lower water absorption capacity, swelling power, solubility and bulk density (loose and packed) than the sun-dried samples. All samples analyzed showed varying solubilities at different pH range.

Keywords: Sun-drying, freeze-drying, functional properties, leafy vegetables.

Introduction

Vegetables are those herbaceous plants whose part or parts are eaten as supporting food or main dishes and they may be aromatic, bitter or tasteless[1]. The utilization of leafy vegetable is part of Africa's cultural heritage and they play important roles in the customs, traditions and food culture of the African household. Nigeria is endowed with a variety of traditional vegetables and different types are consumed by the various ethnic groups for different reasons. The nutrient content of different types of vegetables varies considerably and they are not major sources of carbohydrates compared to the starchy foods which form the bulk of food eaten, but contain vitamins, essential amino acids, as well as minerals and antioxidants[2,3] . According to Okafor[4], vegetables are the cheapest and most available sources of important proteins, vitamins, minerals and essential amino acids. Vegetables are included in meals mainly for their nutritional value; however, some are reserved for the sick and convalescence because of their medicinal properties.

The variety of green leafy vegetables so utilized are as diverse as both the staples with which they are consumed and the localities. for example, it has been estimated that perhaps over sixty species of green leafy plants are so used in Nigeria alone[5,6]. There is seasonal variation in the availability of many of these vegetables. In general these vegetables grow abundantly during the rainy season and are thus most readily available than in the dry season[5]. As earlier indicated, green leafy vegetables are in abundance, during the rainy season in Nigeria but the epileptic power supply prevalence in the country does not give room for wet storage. However, an alternative form of storage used in Nigeria is drying. Due to the increasing consumption rate of dry leafy vegetables during the dry season, there is a need to investigate the effect of different drying methods on the nutrient constituents of some common edible leafy vegetables in the country. Extensive work has been done on the proximate composition, mineral content and anti-nutrient content of sun-dried edible leafy vegetables[7-10]. Little work has been done on the effects of freeze-drying on the parameters mentioned above[11-14]. The focus of the present research work is to establish the effects of both sun-drying and freeze-drying on the functional properties and the protein solubility of the selected vegetable types. The vegetable types are Green amaranth (*Amaranthus hybridus),* Scent leaf *(Ocimum gratissimum),* Basil leaf *(Ocimum basilicum),* Bitter leaf *(Vernonia amygdalina)* and Fluted pumpkin leaf *(Telferia occidentalis).*

Material and Methods

Sample Collection: Vegetable samples used for the research were purchased at Emure-Ile village market in Owo Local Government Area of Ondo State. The stalks were removed and the leaves were rinsed with distilled water and divided into two portions: the first portion sun-dried and the other freeze-dried in Biochemistry Laboratory, Federal University of Technology, Akure.

Sample Preparation: The preparation of the samples for analysis generally involves reduction in amount and simultaneous reduction in particle sizes and thorough mixing of the product so that the portion used represents the average composition of the entire mixture. The sun-dried and the freeze-dried vegetable samples were blended separately using an electronic kenwood blending machine. The sample were ground to small uniform particles of a 40mm mesh size and thereafter stored in airtight moisture proof container prior to analysis.

Determination of Functional Properties: The water absorption capacity (WAC) and fat emulsion stability (FES) were determined by the procedure of Beuchat[15]. The fat absorption capacity (FAC) was determined as described by Sosulki[16] and the lowest gelation capacity (LGC), foaming capacity (FC) and foaming stability (FS) were determined using a standard technique described by Coffman and Garcia[17]. The variation of protein solubility with changing pH was determined as described by Sosulki[18].

Determinations were done in triplicate and Analysis of Variance (ANOVA) was carried out using SPSS (version 15). The means were separated using Duncan's Multiple Range Test (DMRT)[19].

Results and Discussion

Tables 1, 2 and 3 showed the functional properties of the drying methods, the mean functional properties of the drying methods and the effects of the drying methods on the functional properties of different leafy vegetables respectively. Table 2 showed that the least gelation of selected vegetable types had no significant difference at P ≥0.05 level. Table 3 showed that drying methods had no significant effect on the least gelation of the selected vegetable samples. The foaming capacities of the freeze-dried samples were significantly higher than the foaming capacity of the sun-dried samples. The mean foaming capacity as affected by sun-drying and freeze-drying were 41.2% and 48.0% respectively. *A. hybridus* had the highest foaming capacity while *O. basilicum* had the lowest. Foaming stability at 1hour showed that *O. gratissimum* had the highest values 7.0±0.4% for freeze-dried sample and 4.0±0.4% for sun-dried sample while *V. amygdalina* had the least value (1.0±0.0%) for both freeze-dried and sun-dried samples. Comparatively, freeze-dried samples had significantly higher foaming stability than the sun-dried samples. The sun-dried *T. occidentalis* had the highest swelling power (63.3±0.2%) while the freeze-dried *T. occidentalis* had the lowest swelling power (41.2±0.2%). Comparatively, sun-dried samples had significantly higher mean swelling power (54.9%) than the freeze-dried samples of mean swelling power (46.5%). *V. amygdalina* had the highest swelling capacity (15.0±0.7%) for the freeze-dried sample and 13.0±0.4% for the sun-dried sample. The mean swelling capacity of freeze-dried samples (10.0%) was significantly higher than the mean swelling capacity of sun-dried sample (9.6%). The solubility of sun-dried samples ranged between 3.55±0.04% in *V. amygdalina* to 7.03±0.05% in *T. occidentalis* with mean value 5.67% while the solubility of freeze-dried samples ranged between 2.90±0.08% in *V. amygdalina* to 6.24±0.08% in *T. occidentalis* with mean value 4.93%. Comparatively, sun-dried samples had significantly higher solubility than freeze-dried samples at P>0.05level similarly, water absorption capacity of sun-dried sample ranged between 135.4±0.3% in *O. basilicum* to 162.1±0.4% in *T. occidentalis* while the water absorption capacity of sun-dried samples ranged between 134.1±0.3% to 160.8±0.4% in *O. basilicum* and *T. occidentalis* respectively. Comparatively, the water absorption capacity of sun-dried samples was significantly higher than the water absorption capacity of freeze-dried samples. The bulk densities (loose and packed) were significantly higher in sun-dried samples (0.40 and 0.53 respectively) than in freeze-dried samples (0.29 and 0.41 respectively).

The samples analyzed generally had multiple minimum and maximum solubilities. In figure 1, *A. hybridus* had its maximum solubility at pH 9 and minimum solubility (isoelectric point) at pH 6, in figure 2, *O. basilicum* had maximum solubility at pH11 and minimum solubility (isoelectric point) at pH 7, in figure 3, *O. basilimun* had maximum solubility at pH11 and minimum solubility at pH 9, in figure 4, *V. amygdalina* had maximum solubility at pH11 and minimum solubility at pH10 while in figure 5, *T. occidentalis* had maximum solubilities at pH3 and pH11, and minimum solubility at pH 6. Comparatively, the protein solubilities of the freeze-dried samples were higher than the protein solubilities of the sun-dried samples. The isoelectric point of the leafy vegetable samples investigated ranged between pH6 to pH10.

Table 1b showed that drying methods had no significant effect on the least gelation of the selected vegetable samples. The least gelation capacities of both the sun-dried and the freeze-dried vegetable samples were lower than that of *Sorghum bicolor* L stem flour (10%) reported by Oshodi and Aletor[18]. These values show that the very dried vegetable samples may be used as gel forming agent in food formulations and or in new products development for animals[20]. *A. hybridus* had the highest foaming capacity while *O. basilicum* had the lowest. The foaming capacities of the freeze-dried samples were significantly higher than the foaming capacity of the sun-dried samples. High foaming capacity indicates higher solubilized native protein[18]. The foaming capacities of the vegetable samples analyzed were higher and better than the 7.8% obtained for full-fat Beniseed flour[21]. This suggests that the leaves contain reasonable amount of native protein. The foaming stabilities at 1hour of the vegetable samples analyzed were comparable to the reported value of *Sorghum bicolor* L. stems flour (2%) and full-fat fluted pumpkin seed flour (10.8%) by Fagbemi and Oshodi[22]. Foaming stability showed that *O. gratissimum* had the highest values for freeze-dried sample and for sun-dried sample while *V. amygdalina* had the least value for both freeze-dried and sun-dried samples. Comparatively, freeze-dried samples had significantly higher foaming stability than the sun-dried samples. The sun-dried *T. occidentalis* had the highest swelling power while the freeze-dried *T. occidentalis* had the lowest swelling power. Comparatively, sun-dried samples had significantly higher mean swelling power than the freeze-dried samples and *V. amygdalina* had the highest swelling capacity. The mean swelling capacity of freeze-dried samples was significantly higher than the mean swelling capacity of sun-dried sample. Comparatively, sun-dried samples had significantly higher solubility than freeze-dried samples at P>0.05 similarly, the water absorption capacity of sun-dried samples was significantly higher than the water absorption capacity of freeze-dried samples. This may be as a result of the helical chain of protein in sun-dried samples which became unfolded as a result of the effect of heat on the samples and this increased the water absorption capacity of the samples. The WAC of all the samples analyzed were higher than that of raw fluted pumpkin seed flour (40%) reported by Olaofe *et al*[23]. WAC characteristic represents the ability of product to associate with water under conditions when water is limiting such as doughs and pastes[24]. These properties are used in food formulations when interchanging protein sources[23]. Results obtained suggest that the samples may not be useful in food such as bakery products which require hydration to improve handling characteristics[25]. Bulk densities (loose and packed) were significantly higher in sun-dried samples than in freeze-dried samples which might be as a result of the binding water that was more in sun-dried samples that affected the fineness of the particles. These imply that packaging is easier in sun-dry than freeze-dried. The protein solubilities of the freeze-dried samples were higher than the protein solubilities of the sun-dried samples. The isoelectric point of the leafy vegetable samples investigated ranged between pH6 to pH10 which compared favourably with foods protein solubility isoelectric point of range pH 5.5 to pH10 as reported by Ng and Wee; Reddy *et al*[25,26]. It was obvious that drying methods had no effect on the maximum and minimum solubility's pH but affected the percentage solubility. These results indicated that both freeze and sun-dried samples might be used in acidic and basic food products e.g. carbonated drinks and mayonnaise.

Table-1
Functional Properties of Selected Vegetable Types as Affected by Drying Method

Functional Properties	**Drying Methods**	**Name of Vegetable**				
		Amaranthus hybridus	***Ocimum gratissimum***	***Ocimum basilicum***	***Vernonia amygdalina***	***Telferia occidentalis***
Least gelations (%)	sundrying	6.0±0.0^{a}	4.0±0.0^{a}	4.0±0.0^{a}	4.0±0.0^{a}	4.0±0.0^{a}
	freezedrying	8.0±0.0^{a}	4.0±0.0^{a}	6.0±0.0^{a}	6.0±0.0^{a}	4.0±0.0^{a}
Foaming capacity (%)	sundrying	89.4±0.4^{b}	17.7±0.3^{h}	18.1±0.3^{h}	60.0±0.4^{d}	20.8±0.1^{g}
	freezedrying	96.8±0.3^{a}	31.8±0.4^{e}	21.4±0.3^{g}	61. ±10.1^{c}	29.1 ±0.1^{f}
Foaming stability @60	sundrying	2.0±0.0^{e}	4.0±0.4^{c}	2.0±0.0^{e}	1.0±0.0^{f}	3.0±0.4^{d}
	freezedrying	4.0±0.0^{c}	7.0±0.0^{e}	3.0±0.4^{d}	1.0±0.0^{f}	5.0±0.0^{b}
Swelling power (%)	sundrying	51.5±0.7^{cd}	61.3±0.2^{b}	52.1±0.3^{c}	46.2±0.2^{f}	63.3±0.2^{a}
	freezedrying	46.1±0.6^{f}	51.1±0.3^{d}	49.2±0.2^{e}	45.0±0.4^{g}	41.2±0.2^{h}
Swelling capacity (%)	sundrying	10.0±0.2^{c}	10.0±0.0^{c}	5.0±0.1^{d}	13.0±0.4^{b}	10.0±0.4^{c}
	freezedrying	10.0±02^{c}	10.0±0.2^{c}	5.0±0.1^{d}	15.0±0.7^{a}	10.0±0.4^{c}
Solubility (%)	sundrying	5.81±0.00^{d}	5.99±0.06^{c}	5.96±0.04^{c}	3.55±0.04^{g}	7.03±0.05^{b}
	freezedrying	4.93±0.09^{f}	5.58±0.02^{e}	5.01±0.01^{f}	2.90±0.08^{h}	6.24±0.01^{f}
Bulk density (loose)	sundrying	0.47±0.00^{a}	0.41±0.01^{b}	0.35±0.00^{c}	0.34±0.02^{cd}	0.42±0.00^{b}
	freezedrying	0.33±0.01^{d}	0.31±0.01^{e}	0.25±0.01^{h}	0.27±0.00^{g}	0.29±0.01^{f}
Bulk density (packed)	sundrying	0.63±0.00^{a}	0.55±0.00^{b}	0.49±0.00^{d}	0.44±0.01^{e}	0.53±0.00^{c}
	freezedrying	0.42±0.00^{f}	0.41±0.00^{fg}	0.40±0.01^{gh}	0.43±0.00^{e}	0.39±0.01^{h}
Water absorption capacity (%)	sundrying	141.2±0.3^{g}	145.9±0.3^{e}	135.4±0.3^{i}	149.8±0.2^{c}	162.1±0.4^{a}
	freezedrying	140.3±0.2^{h}	145.2±0.3^{f}	134.1±0.3^{j}	148.7±0.2^{d}	160.8±0.4^{b}

Values in the same column having the same superscript are not significantly different of P≥0.05level

Table-2
Mean Functional Properties of Selected Vegetable Types

Name of vegetable	**Least (%) gelation**	**Foaming (%) capacity**	**Foaming stability @ 60min**	**Swelling power (%)**	**Swelling capacity (%)**	**(%) solubility**	**Bulk density (loose)**	**Bulk density (packed)**	**Water (%) absportion capacity**
Amaranthus hybridus	7.0^{a}	93.1^{a}	3.0^{c}	10.0^{b}	5.37^{d}	0.40^{a}	0.52^{a}	140.8^{d}	48.8^{d}
Ocimum gratissimum	4.0^{a}	24.8^{d}	5.5^{a}	10.0^{b}	5.79^{b}	0.36^{b}	0.48^{b}	145.6^{c}	56.2^{a}
Ocimum basilicum	5.0^{a}	19.7^{e}	2.5^{d}	5.0^{c}	5.49^{c}	0.30^{c}	0.45^{d}	134.8^{e}	50.7^{c}
Vernonia amygdalina	5.0^{a}	60.6^{b}	1.0^{e}	14.0^{a}	3.23^{e}	0.31^{c}	0.44^{e}	149.3^{b}	45.6^{c}
Telferia occidentalis	4.0^{a}	23.0^{c}	4.0^{b}	10.0^{b}	6.64^{a}	0.35^{b}	0.46^{c}	161.5^{a}	52.3^{b}

Values in the same column having the same superscript are not significantly different of P≥0.05level

Table-3
Effect of Drying Methods on Mean Functional Properties of Selected Vegetable Types

Name of vegetable	Least (%) gelation	Foaming (%) capacity	Foaming stability @ 60min	Swelling power (%)	Swelling capacity (%)	(%) solubility	Bulk density (loose)	Bulk density (packed)	Water (%) absorption capacity
Sundrying	4.8^a	41.2^b	2.4^b	54.9^a	9.60^b	5.67^a	0.40^a	0.53^a	146.9^a
Freezedrying	5.2^a	48.0^a	4.0^a	46.5^b	10.0^a	4.93^b	0.29^b	0.41^b	145.8^b

Values in the same column having the same superscript are not significantly different of P≥0.05level

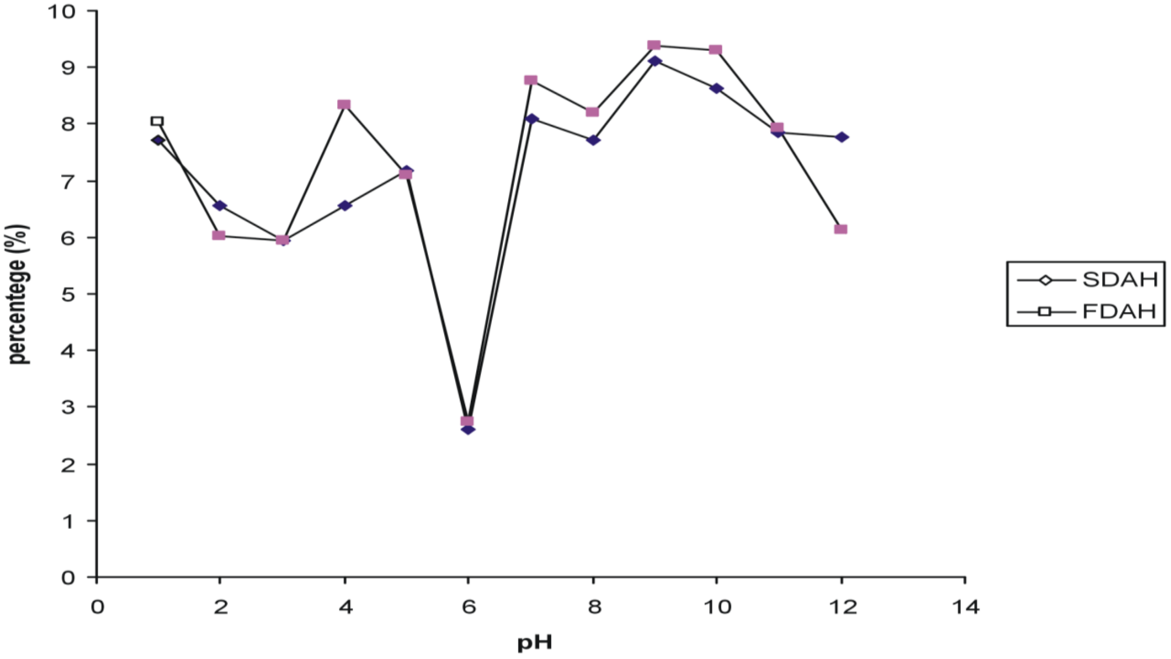

Figure-1
Protein Solubility of Amaranthus Hybridus

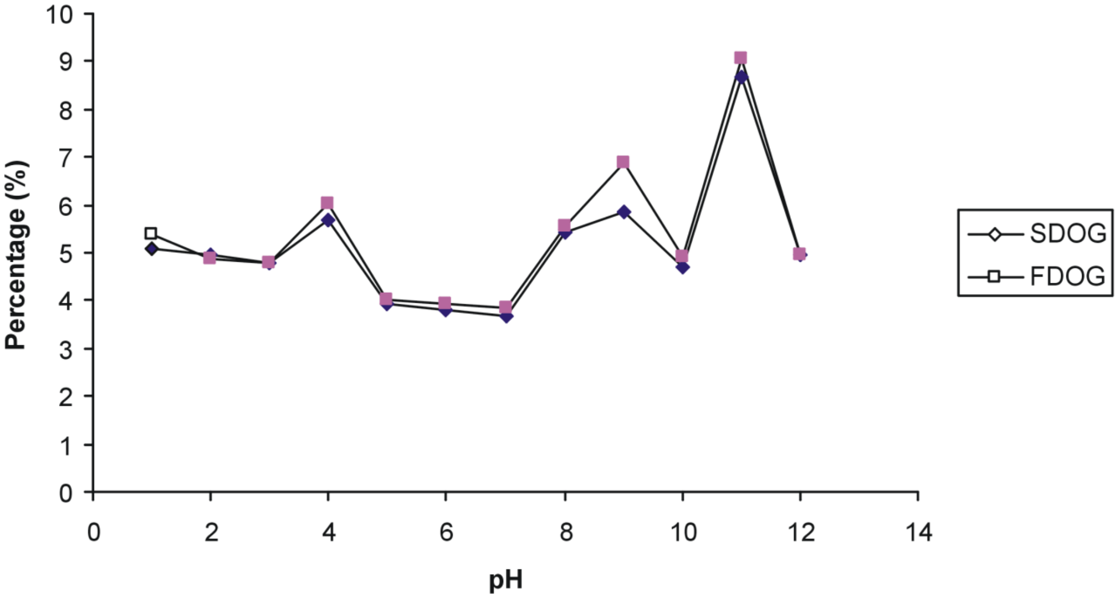

Figure-2
Protein Solubility of Ocimum Gratissimum

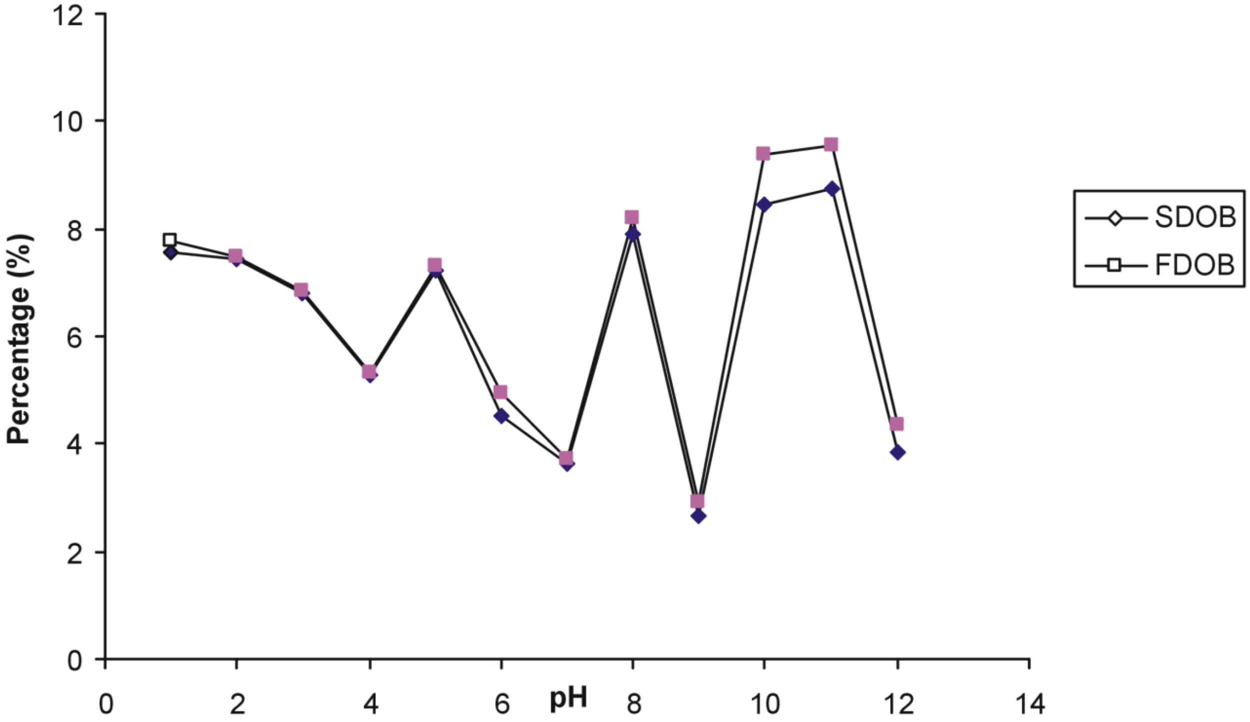

Figure-3
Protein Solubility of Ocimum Basilicum

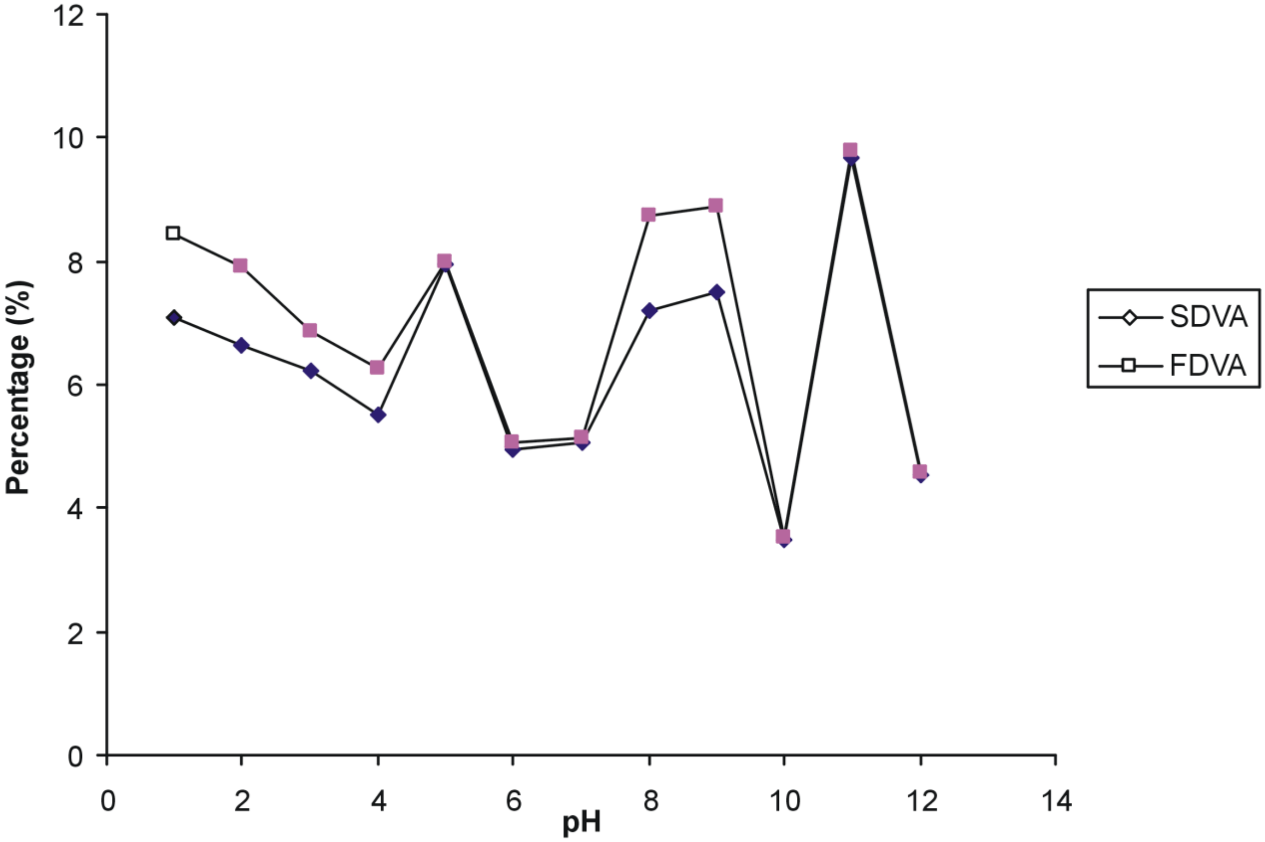

Figure-4
Protein Solubility of Vernonia Amygdalina

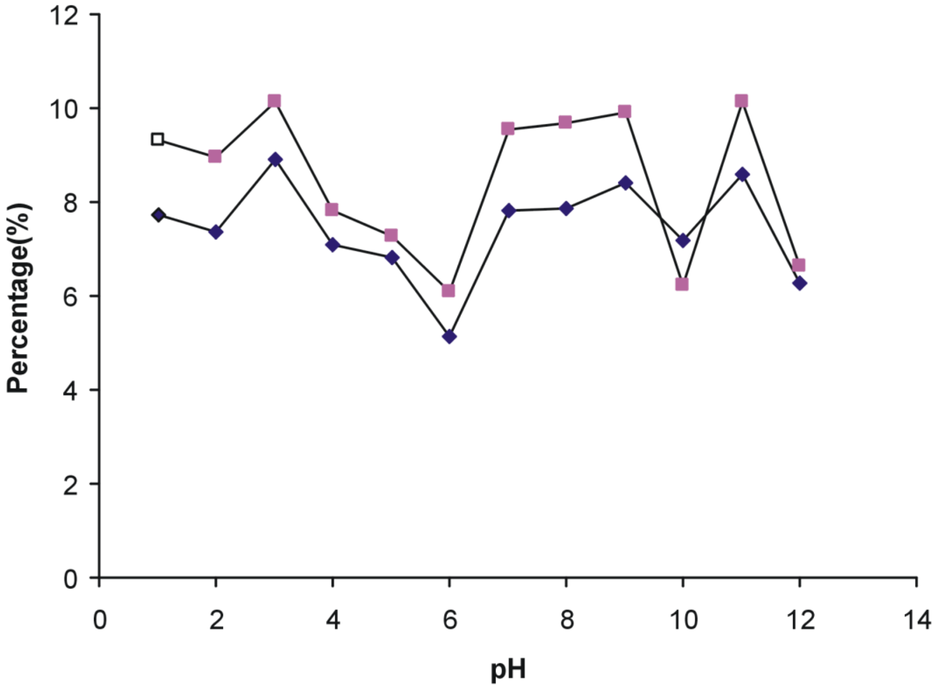

Figure-5
Protein Solubility of Telferia Occidentalis

Conclusion

Freeze-drying had significantly higher (at P<0.05level) foaming capacity, foaming stability and protein solubility but lower water absorption capacity, swelling power, solubility and bulk density (loose and packed) than the sun-dried samples. Of the drying methods, freeze-drying appear to be more promising than sun-drying.

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