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Studies on Spinach Powder as Affected by Dehydration Temperature and Process of Blanching

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Abstract

Spinach (Spinacia oleracea) is an important green leafy vegetable. The leaf of this annual plant is used as major ingredient in Indian cuisine mainly due to its nutritional and therapeutic values. Leaves on detachment from any plant continue rapid transpiration and respiration by natural phenomena and looses their quality within few hours. Therefore, the leafy vegetables including spinach are considered as highly perishable vegetable. The attempts were made to make the spinach leaves to shelf-stable using the process of dehydration in a cabinet drier maintained at different isothermal temperatures ranging from 50 to 80^{0}C with an interval of 10^{0}C. The deterioration in the dehydrated product quality starts with the action of responsible enzymes, thus the effect of blanching treatment was studied. The leaves dehydrated at subjected different temperatures were crushed manually and late using mixer grinder. The characterization of dehydrated leaf powder in mixed, coarse and fine fractions were carried out on the basis of physical and optical parameters. The studied properties were found to be governed by dehydration temperature, treatment applied and on particle size. The dehydration temperature of 60^{O}C for unblanched and 70^{O}C for blanched spinach could be used for production of enhanced quality green leafy vegetable powder of wider acceptability.

Keywords: Spinacia oleracea; spinach; dehydration; powder; characterization.

1. Introduction

Spinach (*Spinacia oleracea)* as green leafy vegetable, low in calories is considered as a good source of vitamins (ascorbic acid, riboflavin, niacin and folic acid), minerals (iron and calcium) and dietary fibers. It is a popular vegetable and consumed fresh as well as processed as raw, boiled or cooked into various delicacies (Ozkan et al, 2007; Nisha et al, 2005). Its dark green colour changes to olive green on thermal processing mainly due to conversion of chlorophyll into pheophytin and pyropheophytin. The process of chlorophyll degradation was found to be slow at lower temperatures. Blanching as a mild heat treatment often used to cease the process of discoloration by inactivating the responsible enzyme. Reduction of moisture content to a lower level makes the product shelf stable over an extended period of time. Also, it endow with several benefits of substantial weight reduction and reduction in volume, minimizing the packaging cost with storage and transportation costs (Doymaz, 2004, 2007). Preservation in lean seasons at remunerative prices could provide additional benefits of round the year availability of this important leafy vegetable. Considered the above mentioned importance the study was conducted on the determination of characteristics of developed shelf-stable *Spinacia oleracea* leaf powder so as to use directly in the development of various food formulations.

2. Materials and Methods

2.1 Sample Preparation

Spinach leaves (Palak RNG-All Green Akshit) were harvested during early morning from local farm of nearby Longowal village and brought to Food Engineering and Technology Department, Sant Longowal Institute of Engineering and Technology (SLIET), Longowal, Punjab. Fresh and undamaged leaves were separated, washed to remove foreign matter such as dust, dirt, chaff and immature leaves using tap water. The recovery of usable portions of spinach leaf was found in order of 45.753±2.616% from the harvested portions. The moisture content of fresh spinach leaves was found to be 91.81±0.01% (wwb). Drying behaviour of spinach leaves were investigated at four different isothermal temperatures (50, 60, 70 and 80 ^{0}C) in a developed cabinet dryer (Ankita and Prasad, 2013). The dehydration process was carried out for at least three hours durations. The obtained dried samples at different temperatures were subjected for manual crushing initially and further using mixer grinder to get spinach powder for further studies. A set of screens (10-12-16-25-60-85 BSS) was used to classify the powder fractions based on size.

2.2 Powder Characterization

The moisture content of the leaf powders was measured by using a hot air oven method (Ranganna, 1997) and physical properties using standard method as described elsewhere (Prasad et al, 2010). Subsequently, the dehydration characteristics for dehydration ratio, rehydration ratio and coefficient of rehydration were determined (Ranganna, 1997). The optical properties (L; a; b and colour difference, ΔE) was adopted as described by Singh and Prasad, 2013. Water absorption index (WAI) and water solubility index (WSI) were determined as, the ground powder was soaked in water at room temperature for 30 min with gentle stirring and then centrifuged at 3000rpm for 15 min. The supernatant is decanted into an evaporating dish of known weight. The WSI is the weight of dry solids in the supernatant expressed as a percentage of the original weight of sample. The WAI is the weight of residue as obtained after removal of the supernatant and expressed as per unit weight of original dry solids.

The statistical analysis for the data of obtained in triplicate were evaluated with mean separation to determine any statistically significant effects prevailed among them (Singh and Prasad, 2013).

3. Results and Discussion

The effect of blanching and dehydration temperature on the dehydrated spinach leaves are shown in Fig. 1 with the spinach leaf powder characteristics shown in Table 1. The quality of dehydrated spinach leaf powder was found to be treatment and temperature dependent as per the variations in the observed physical and optical parameters. The increase in dehydration temperature from 50 to 80^{O}C led to the dehydrated powders having lesser moisture content, which was reduced from 4.86 to 1.71% in case of untreated leaves and 5.89 to 2.92 % in case of blanched spinach leaf samples. Further, it was reflected to have more moisture retention capacity of blanched leaves in comparison to the untreated leaf samples at every dehydration temperatures (Table 1). This trend could very well be reflected with the change in the dehydration ratio data, which ranged from 11.66 to 12.02 for untreated and 11.34 to 11.67 for the blanched spinach leaves.

Figure 1: Dehydrated spinach leaves.

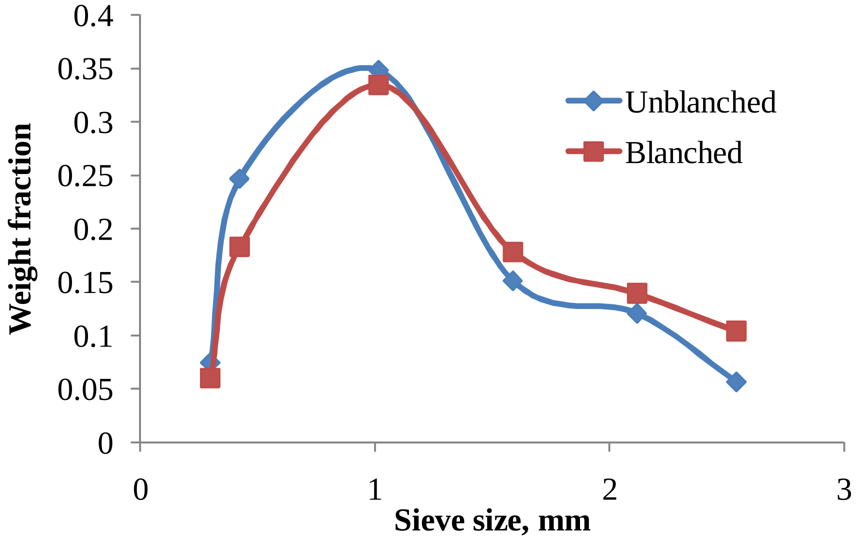

Figure 2: Size dependent powder weight fraction.

Bulk densities of the dehydrated powder was found to have increasing trend with increase in temperature of dehydration but the process of blanching has resulted in a dehydrated product of increased bulk density may be due to more structural changes during blanching and formed the compact structure on dehydration than the counterpart. This could further be justified with the less rate of increase in bulk density in case of unblanched powder but the differences in the bulk densities are more for the blanched leaf powder on increasing the dehydration temperatures. Coefficient of friction as frictional property for the spinach powder obtained by dehydrating at various temperatures was assessed and found to be temperature dependent considering the direct effect with increasing trend. This may indirectly governed on the particle size, moisture content, structure of the particle and the adhesive force of the particles and that of the studied contact surfaces. The decrease in angle of repose (AOR) for unblanched spinach powder but the increase was noticed for the blanched spinach leaf powder (Table 1). Leaf powder from blanched leaves exhibit higher degree of cohesiveness and these granular materials possess higher frictional characteristics thus coefficient of friction is showing significant variation at different temperatures and surfaces.

Table 1: Properties of spinach leaf powder, dehydrated at different temperatures.

Physical properties	Spinach leaf powder				
		50 ^{O}C	**60 ^{O}C**	**70 ^{O}C**	**80 ^{O}C**
Moisture, %(d.b.)	(UB)	4.86±0.03	4.42±0.04	3.31±0.04	1.71±0.10
	(B)	5.89±0.07	5.35±0.05	4.82±0.03	2.92±0.04

Bulk Density, g/cm^3	(UB)	0.411±0.009	0.413±0.004	0.423±0.006	0.439±0.007
BD g/ cm^3	(B)	0.462±0.003	0.496±0.059	0.506±0.037	0.576±0.031
AOR, Degrees	(UB)	44.708±4.010	42.306±2.459	39.528±1.710	41.697±2.585
	(B)	38.722±2.554	37.241±1.395	39.467±2.839	39.402±3.832
COF					
Glass	(UB)	0.211±0.002	0.279±0.002	0.260±0.011	0.268±0.005
Plastic board	(UB)	0.368±0.010	0.307±0.018	0.346±0.036	0.407±0.004
Steel	(UB)	0.337±0.013	0.341±0.007	0.387±0.005	0.365±0.006
Plywood (longitudinal)	(UB)	0.337±0.005	0.359±0.007	0.373±0.008	0.359±0.002
plywood (transverse)	(UB)	0.392±0.004	0.395±0.014	0.396±0.013	0.411±0.002
Glass	(B)	0.230±0.004	0.263±0.011	0.272±0.006	0.381±0.006
Plastic board	(B)	0.368±0.008	0.274±0.005	0.361±0.026	0.379±0.007
Steel	(B)	0.331±0.006	0.329±0.007	0.389±0.003	0.383±0.011
Plywood (longitudinal)	(B)	0.263±0.198	0.337±0.002	0.371±0.009	0.414±0.007
plywood (transverse)	(B)	0.367±0.009	0.329±0.004	0.413±0.000	0.272±0.006
L-value	(UB)	54.19±6.03	51.19±2.33	50.05±1.92	48.30±0.81
	(B)	53.11±0.26	52.06±2.51	52.71±0.57	51.78±3.95
a-value	(UB)	-4.62±1.75	-2.99±1.27	-2.46±0.67	-2.57±1.60
	(B)	-2.07±3.70	-2.14±2.96	-2.80±3.69	-1.86±2.21
b-value	(UB)	13.80±5.27	13.28±3.20	13.83±3.51	13.16±1.15
	(B)	18.13±2.59	17.03±1.96	15.97±1.38	14.22±4.23
Dehydration ratio	(UB)	11.658±0.027:1	11.707±0.232:1	11.833±0.0319:1	12.019±0.219:1
	(B)	11.339±0.212:1	11.397±0.066:1	11.454±0.043:1	11.665±0.302:1
WAC, g/g	(UB)	1:2.454±0.037	1:2.224±0.106	1:2.232±0.085	1:2.212±0.089
	(B)	1:2.588±0.096	1:2.572±0.237	1:2.472±0.067	1:2.422±0.019
WSI, %	(UB)	2.880±0.282	2.800±0.113	2.620±0.084	3.180±0.141
	(B)	3.060±0.141	2.800±0.113	2.880±0.113	3.160±0.000

where, UB- Unblanch, B- Blanch, BD- Bulk density, AOR- Angle of repose, COF- Coefficient of friction, L- value - degree of brightness/darkness, a-value- degree of redness/greenness, b-value - yellowness/ blueness, WAC – Water absorption capacity, WSI- Water solubility index

Water absorption capacity (WAC) and water solubility index (WSI) values were determined as an indicator of degradation of molecular components. It was found that WSI increases as the size of the particle decreases, whereas WAC decreased as the particle size decreases. For coarse particles moisture diffusion occurred at a higher rate. Thus, the structure of powder reflects more porous, which has resulted in increased weight of sediment reflected more WAC.

There was decrease in greenness after blanching and drying as a-value changed from initial value of -8.937 for fresh spinach to -4.62 to -2.57 for the powder obtained from unblanched leaves and -2.07 to -1.86 for blanched one. The L- value was found to have 48.30 to 54.19 for unblanched powder and 51.78 to 53.11 for blanched spinach powder and found in accordance with previous studies (Ahmed et al, 2002). Also, the increase in dehydration temperature has affected the brightness and greenness of dehydrated product adversely (Table 1). It is further reflected that the better spinach powder could be obtained using the dehydration temperature of 60^{O}C for unblanched and 70^{O}C for blanched spinach.

4. Conclusion

Physical and optical properties of spinach leaf powder are temperature dependent, particle size dependent and treatment has effect on it. Blanched powder was found more compact structure with more moisture content as compared to the unblanched leaf powder. The dehydration temperature of 60^{O}C for unblanched and 70^{O}C for blanched spinach could be used for production of enhanced quality green leafy vegetable powder of wider acceptability.

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