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Characterization of dehydrated functional fractional radish leaf powder

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ABSTRACT

Radish (Raphanus sativus L) is the one of the most ancient, widely cultivated, quick growing, cool season, cold tolerant root vegetable of Brassicaceae family. Leaves, roots and seeds of radish has variety of health benefits and used in the treatment of various diseases. The entire plant of radish is eatable. Increase in the fecal excretion of total lipids, triglycerides and total cholesterol on consumption of radish found helpful in cardiovascular disease (CVD) and delayed aging with inhibiting tumor growth preventing the occurrence of cancer. Green leafy vegetables are highly seasonal, therefore available abundantly at cheaper rates during peak season and results in the spoilage due to glut. Considering the enormous importance of this underutilized leafy vegetable, pretreatment at blanching and dehydration temperature and on physical, optical and chemical characteristics of radish leaf powder in order to improve the process for preparation and to develop and explore as functional ingredient to be used for various food products. It was found that the physical, chemical and optical properties of radish leaf powder were treatment and temperature dependent. Blanching of radish leaf prior to dehydration resulted into a powder of compact structure while the untreated radish leaf into more porous structure. The powder obtained under the combination temperature dehydration of 80°C as initial and 70°C as finishing temperature without any additional treatment (improved technique) gave a powder of higher quality, which was further improved on fractionation. The fine powder fraction was found rich in phyto chemicals and found comparatively more acceptable as functional material to be used to make the food full of therapeutic values.

Keywords: *Raphanus sativus;* Radish; dehydration; powder; characterization

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INTRODUCTION

Radish (*Raphanus sativus* L) is the one of the most ancient, widely cultivated, quick growing, cool season, annual or biennial, cold tolerant but heat sensitive root vegetable of Brassicaceae (Cruciferae) family[1-2]. Brassicaceae crop provides greatest diversity worldwide in the products used by man. This family is a monophyletic group consisted of 338 genera and around 3709 species grown extensively on economic aspects especially deliver leaf, flower and root vegetables, oil, condiment, food, fodder and ornamentals [3-4].

Agricultural innovations are striving towards cultivating vegetables of improved nutrition and functionality to provide healthy diets [5]. The uses of plants of importance are widely reported in Ayurveda, which have therapeutic, preventive and curative properties [6]. Plant provides varieties of cancer-preventive phytochemicals in form of polyphenols, terpenes, indols and sulphur containing compounds [7]. Cruciferous vegetables which include radish, cauliflower, cabbage, broccoli, Brussels sprouts, Kohlrabi, mustard, kale and others are known for protection against cancer mainly by supplying the bioactive compounds, glucosinolates, a water soluble precursor of isothiocyanates, the pungent principle of radish [8]. Leaves, roots and seeds of radish or *muli* commonly known in India has variety of health benefits and used in the treatment of various diseases. Glucosinolate acts as the defence against fungal diseases and pest infestation, sulphur and nitrogen metabolism, and growth regulation in the plant [9]. The most characterized glucosinolates are sulforaphane, phenylethyl isothiocyanate, allyl isothiocyanate and indole-3-carbinol. The 3-indolymethyl glucosinolate was reported to be low in seed but dominants indole glucosinolate in the leaf [10]. Catalase, superoxide dismutase, glutathione peroxidase activities in red blood cell and liver were increased with decrease in xanthine oxidase activities on radish consumption, which supports the use for the years to treat jaundice as it acts as a good detoxifier especially for the liver. Further, the increase in the fecal excretion of total lipids, triglycerides and total cholesterol on consumption of radish found helpful in cardiovascular disease (CVD) and delayed aging with inhibiting tumor growth preventing the occurrence of cancer by 30 - 50% [11]. As roughage, fiber improves gut health so found to be useful for different gastrointestinal disorders. The diuretic properties of radish are used to treat the urinary disorders. The caffeic acid and pelargonidin are antiviral and found to affect against influenza virus [12]. The lipo-polysaccharides showed anti-herpes activity. The presence of histaminergic component with weak spasmolytic factor supposed to be in the traditional use for curing the problem of constipation [13]. Radish leaves are rich source of calcium, iron and ascorbic acid and on consumption with rice, the phytin helps in calcification process. As it is good source of potassium, it is found helpful in maintaining the blood pressure. Radish is found to help in the creation of collagen, which strengthens the blood vessels and thus reduce the risk of atherosclerosis.

Green leafy vegetables are highly seasonal, therefore available abundantly at cheaper rates during peak season and results in the spoilage due to glut [14]. These have distinctive proposition among eatables because of their colour, flavor and health benefits [2, 15]. The entire plant of radish is eatable. The underground modified root of this short season vegetable is normally consumed as salad vegetable and the tops as leafy vegetable. Even leaves of radish are stir fried to add a little zest to the prepared food. The leaves of radish are good source of protein and found to have biological value of 76.6 with the digestibility co-efficient of 73.5% may be due to the presence of nitrogenous fraction of present twenty two amino acids.

Leaf is a thin, dorsiventral flattened organ of a vascular plant having appendage with the stem and responsible for photosynthesis. Leaves and stem together form shoot, whereas the entire shoot form the foliage. The immature leaves of foliage are soft but have high metabolic rate [16] and possess chlorophyll, a green colored pigment an important quality attribute. The cell wall and cell membrane give structure. The water filled cytoplasm provides turgidity to the cells and is responsible for the crispness of fruits and vegetables. The hydrostatic pressure in the cytoplasm decreases on removal of water and thus results in the wilting [16]. Transpiration of leaves result in the loss of water and thus affect the cell turgor, which is essential for maintaining the textural characteristics [17]. Respiration on the other hand is a catabolic process in which the stored carbohydrates are converted into energy and heat releases. All of these lead to the senescence, a natural change in the plant, which cause inevitably the death of cells [18]. The process of senescence if fully understood then the confirm date of expiry or usability limit even for any perishable commodities such as fruits and vegetables could be predicted very well in advance. Attempts are being made by the author to correlate the parameters to confirm the date of expiry of senescing fruit based on the observable parameters in using non destructive approach [19]. Since, the postharvest life of perishable commodity such as radish leaves are decided by the extrinsic environmental variables [20] and the intrinsic variables such as chemical constituents having high moisture content and the physical parameters such as excessive surface area to thickness ratio of the leaf, being the shape similar to sheet. This leads to quality deterioration in very short durations. This concept has been utilized to obtain accelerated moisture reduction during the dehydration process in order to reduce the water activities with controlling the enzymatic activity for quality dehydrated produce [21-24]. Thus, it is important to determine the properties of dehydrated product for the design and development of food processing equipment [25]. Considering the above mentioned importance, the underutilized leafy vegetable of radish was assessed for the temperature and treatment based physico-chemical and optical characteristics of radish leaf powder in order to develop and explore as functional ingredient for the food and pharmaceutical products.

MATERIALS AND METHODS

Sample Preparation

Radish with its foliage of variety NBH-White Queen was uprooted from the soil during early morning from the local farm of nearby Longowal village and brought to Pilot plant of Food Engineering and Technology, S. L. I. E. T., Longowal, Punjab within 30 minutes time. After separation of foliage from the root, the fresh and undamaged leaves were separated. Yellow and unwanted mature leaves as well as hard stems were removed and the usable separated leaves were washed in the running tap water at least twice to remove foreign matter such as dust, dirt and chaffs. Steam blanching as pretreatment was subjected to the radish leaves for 2 minutes in a developed steam blancher consisted of two chambers, one as steam generation chamber and other as steam generation cum blanching chamber [21]. The combined pressure vessels with control units served effective blanching. Similarly, developed precision dehydration chamber equipped with automated control and data acquisition system [24] was used to get the dehydrated leaves dried at different isothermal conditions (50, 60, 70, 80 and 90^{0}C) without any disturbance during dehydration process. The dehydration kinetics and the characteristics of resultant products were compared (unpublished data). On analysis of the data the combination temperature of dehydration was identified as initial 80^{0}C for 1 hour and rest 2 hours at 70^{0}C as finishing temperature. The obtained dried samples were manually crushed before using mixer grinder to get powder. The analysis of particle size distribution further used to identify the screen size to fractionate the powder [2] into fine and coarse fractions. The identified screen 60 BSS was applied and found the fine fraction rich in phytochemicals.

Physico-Optico-Chemical Characteristics
Moisture content of samples was measured using hot air oven method [26] and dimensional characteristics using the method described elsewhere [27]. Bulk density as gravimetric property, angle of repose and coefficient of friction as frictional characteristics and L, a and b values as optical characteristics were evaluated following standard method as reported [28-29]. Water absorption capacity (WAC) and water solubility index (WSI) were determined [23]. The dehydration characteristic as dehydration ratio was assessed [26].

Chemical characteristics as proximate composition for the analysis of protein, fat, carbohydrate and ash content were assessed using the standard method [26]. The presence of phyto-chemicals from the hexane extract of radish powder was identified using gas chromatography and mass spectroscopy (GC-MS), Shimadzu GC-MS 2010. Nitrogen gas was used as carrier maintained at 10 PSI inlet pressure with FID and AB inno-wax column (60 m X 0.25 mm ID, film thickness 0.25 μm). Injector and detector temperatures kept at 270˚ and 280˚C, respectively. Column temperature is programmed from 60˚ to 180˚C at 3˚C/min ramp with hold time of 2 min and from 180˚ to 250˚C at 5˚C/min ramp with hold time 20 min, respectively. The flow rate of carrier gas was maintained at 1.2 ml/min and split ratio was 80:1. The data were processed on GCMS solutions software for identifying the possible constituents. Helium was used as carrier gas. EI source and mass range were 70 eV and 40-750 amu, respectively. The identification of the components was assigned by comparing their GC retention times with those of authentic samples as well as with known components of standard fragmentation pattern with that of NIST and Wiley computer libraries [30].

Statistical Analysis
The data was obtained at least in triplicates for the statistical analysis. Mean separation was applied to assess any statistically significant effects prevailed among the subjected treatments. A multiple comparison of the treatment means was performed by Duncan's Multiple Range Test and the level of significance for the difference was determined at $p \leq 0.05$ [31-32].

RESULTS AND DISCUSSION

Characteristics of Fresh Leaves
The recovery of edible root portion of radish was found to be in the range of 38.04 to 62.84% in a five different size groups from small to large radish with an average recovery as 49.86±8.90%. The recovery of remaining aerial portion as foliage was found to vary from 37.16 to 61.96% from large to small size radish groups. The lesser recovery of foliage was noticed for the radish having longer sized root. The edible soft leafy portions from the foliage were at an average level of 15.51±2.38% out of whole plant and 49.93±1.13% on considering the recovery from foliage (Figure 1). The recovered fresh leaf moisture content was found to be 87.50% (Table 1). The chlorophyll and carotene content of raw radish leaves were found to be 105.76±5.06 mg/100gm and 3.96±0.45 mg/100gm, respectively. The corresponding leaf color of fresh radish in terms of Lightness (L value), greenness (negative a value) and yellowness (positive b value) varied in the range of 60.79±0.88, -8.41±0.07 and 23.14±1.29, respectively.

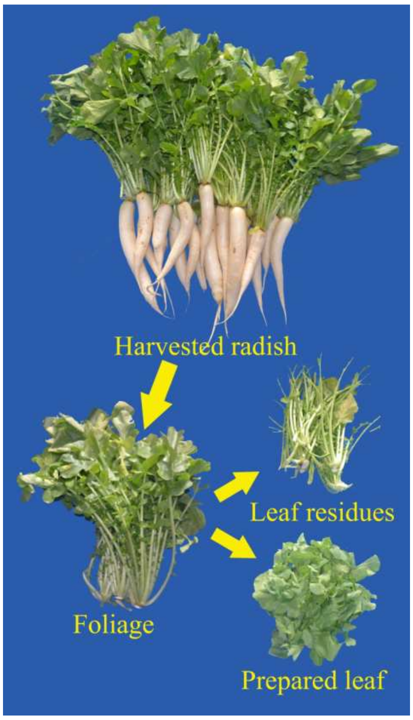

Figure 1. Mapping steps of functional radish leaf powder production

Table 1. Properties of radish leaves

Parameters	Values
Leaf recovery, %	45.42±6.10
Moisture content, %	87.50±2.21
L-value	60.79±0.88
a-value	-8.41±0.07
b-value	23.15±1.29
Chlorophyll total, mg/100g	105.76±5.06
β-Carotene, mg/100g	3.96±0.45

Chlorophyll is the main green pigment of green leafy vegetable and yellowing of fresh leaf is considered as an important quality associated defect [33]. The process is due diminishing masking effect of chlorophyll on carotenoid pigment, which is possibly by the mechanism of chlorophyll breakdown to colorless entity (Figure 2). The polyphenol oxidase catalyzed enzymatic browning leading to polymerization into brown melanoidines, although insignificant but also associated with leaf discoloration to some extent and needs to be controlled by thermal treatment to maintain the quality attributes. Blanching is the mild heat treatment provided mainly to inactivate the associated enzymes responsible for these deteriorations. Effect of blanching and dehydration temperature on the characteristic of dehydrated radish leaf powder was assessed (Table 2).

Effect of Blanching and Dehydration Temperature on Powder Characteristics

The quality of dehydrated radish leaf powder was found to be treatment and temperature dependent as per the variations in the observed physical, chemical and optical characteristics (Table 2). The increase in dehydration temperature from 50 to 90^{0}C led to the dehydrated powders containing lesser moisture content, which was found from 6.54±2.10% to 2.56±0.22% in case of untreated leaves and 8.20±1.68 to 1.23±0.03 % in case of blanched samples. Further, it was found that the blanched samples retained more moisture in comparison to respective untreated samples (Table 2). This trend could very well be justified by the found lower dehydration ratio in case of blanched samples, which is mainly due to the softened leaf on blanching shrunk to form the compact mass also reflected with higher corresponding bulk densities with the higher water retentions (Table 2).

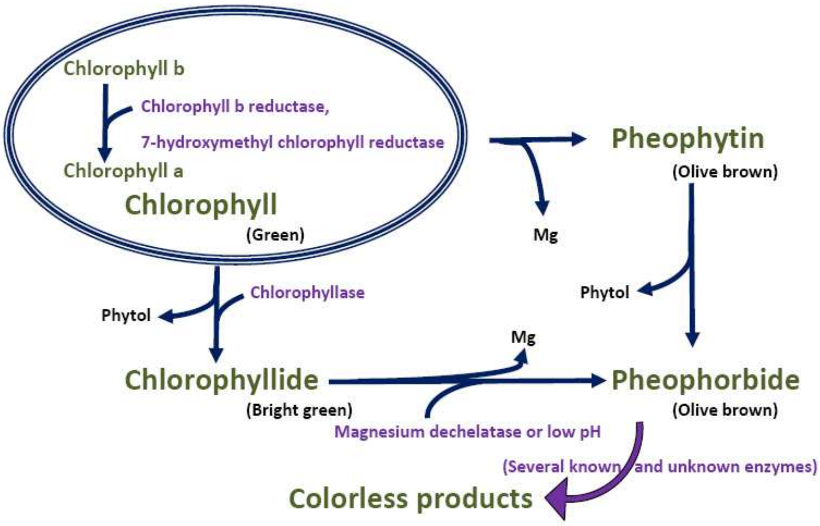

Figure 2. Chlorophyll degradation mechanism

Table 2. Properties of radish leaf powder, dehydrated at different temperatures

Physical properties		**Radish leaf powder**				
		50^0C	**60^0C**	**70^0C**	**80^0C**	**90^0C**
MC, % d.w.b.	(UB)	6.54±2.10	5.42±0.97	3.62±0.48	2.79±0.31	2.56±0.22
	(B)	8.20±1.68	5.89±0.69	3.36±0.18	1.52±0.06	1.23±0.03
BD, kg/m^3	(UB)	478±3.307	521±2.389	536±5.773	535±13.576	530±9.998
	(B)	534±7.234	533±38.682	542±24.110	556±5.773	556±5.773
AOR, degrees	(UB)	54.59±1.15	52.46±1.85	50.95±1.67	44.13±2.85	42.05±2.33
	(B)	49.34±1.48	43.59±3.06	43.09±2.85	38.59±2.57	37.40±1.44
COF Glass	(UB)	0.33±0.01	0.33±0.01	0.30±0.01	0.30±0.01	0.29±0.01
COF Plastic board	(UB)	0.36±0.01	0.36±0.01	0.34±0.01	0.34±0.02	0.33±0.01
COF Steel	(UB)	0.35±0.01	0.34±0.01	0.33±0.01	0.32±0.01	0.32±0.01
COF Plywood (long.)	(UB)	0.59 ±0.01	0.60±0.01	0.58±0.01	0.58±0.01	0.58±0.01
COF Plywood (trans.)	(UB)	0.62±0.01	0.616±0.01	0.615±0.01	0.612±0.01	0.614±0.01
COF Glass	(B)	0.23±0.01	0.23±0.01	0.22±0.01	0.22±0.01	0.22±0.01
COF Plastic board	(B)	0.34±0.01	0.33±0.01	0.32±0.01	0.32±0.01	0.32±0.02
COF Steel	(B)	0.33±0.00	0.32±0.01	0.31±0.01	0.32±0.01	0.32±0.02
COF Plywood (long.)	(B)	0.43±0.02	0.40±0.01	0.39±0.01	0.39±0.01	0.38±0.01
COF plywood (trans.)	(B)	0.62±0.01	0.61±0.01	0.60±0.01	0.61±0.01	0.61±0.01
L-value	(UB)	55.10±0.52	54.09±0.98	50.98±0.76	50.48±0.30	48.23±0.13
	(B)	43.15±0.81	42.40±1.46	41.08±1.11	38.89±1.77	35.29±0.09
a-value	(UB)	-6.19±0.50	-5.53±0.19	-2.12±0.47	-1.39±0.24	-1.39±0.24
	(B)	-3.22±0.39	-4.80±0.86	-3.22±0.39	-3.95±0.61	-2.38±0.08
b-value	(UB)	20.35±0.45	18.97±1.23	15.59±1.15	12.72±0.17	12.72±0.17
	(B)	17.89±0.64	14.89±0.48	15.50±1.92	10.14±0.08	8.91±0.74
DR	(UB)	7.45±0.34	7.50±0.08	7.75±0.18	7.73±0.23	7.77±0.41
	(B)	7.01±0.08	7.24±0.06	7.24±0.03	7.55±0.06	7.56±0.22
WAC, g/g	(UB)	2.64±0.01	2.50±0.03	2.45±0.04	2.49±0.11	2.57±0.01
	(B)	2.82±0.03	2.89±0.01	2.65±0.06	2.55±0.04	2.52±0.06
WSI, %	(UB)	20.60±0.85	21.2±0.57	22.40±1.13	21.40±0.84	25.00±0.28
	(B)	25.00±01.97	25.20±0.17	36.60±0.84	35.80±0.28	31.20±1.13
Chlorophyll (mg/100g)	(UB)	539 ±28.07	456±23.53	418±96.98	331±47.08	294±42.73
	(B)	614 ±48.76	578±4.85	484±24.78	433±11.44	375±63.01
β-carotene, (mg/100g)	(UB)	31.07±2.96	30.73±2.70	29.30±0.68	29.85±1.14	25.80±0.86
	(B)	32.76±1.55	31.09±4.83	31.78±2.81	32.91±1.44	32.21±1.49

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 – degree of yellowness/ blueness, WAC – Water absorption capacity, WSI- Water solubility index

Similarly, the water absorption capacity as well as water solubility index was found to be more in case of blanched samples dehydrated up to a temperature of 80^0C. The present findings are in tune with the findings of the dehydration characteristics as observed for other leaves [30]. A relatively low content of water and hygroscopicity are principle characteristics of food powders which differentiate the powder from other food products. Powders of found porous structure with highly fragmented dried products behave as hygroscopic even under low and medium humidity situations (Figure 3). Apart from its influence on the physical characteristics, the moisture content of food powders play important role in quality stability and pose direct problems during handling, packaging, transportation and storage [34]. The average particle size of dehydrated powdered mix was noticed to have 198.783±0.336µm (Figure 4).

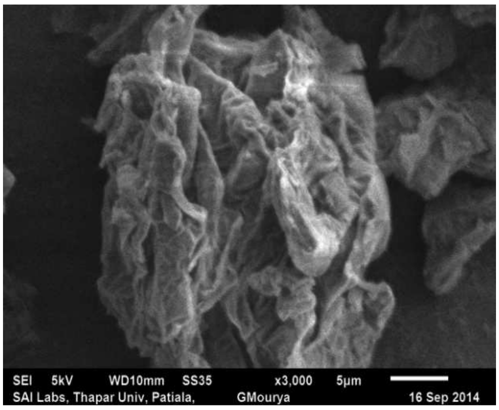

Figure 3. SEM image of fine radish powder at 3000X

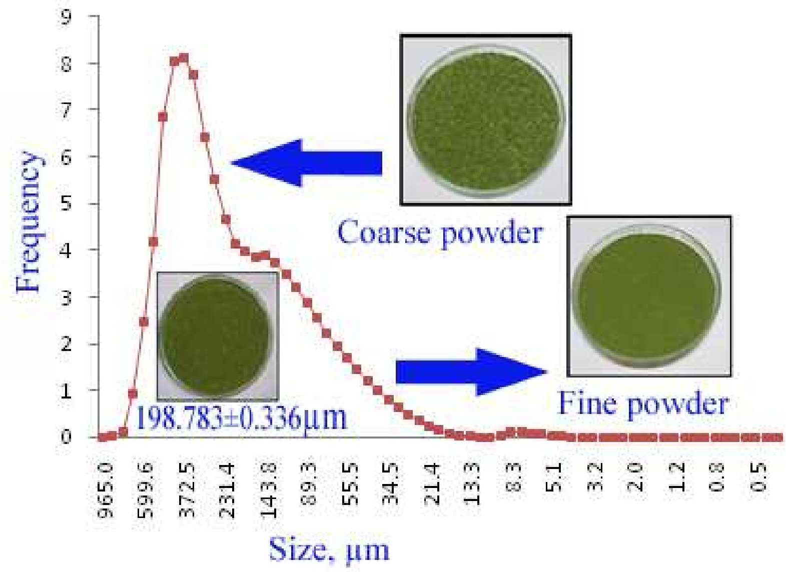

Figure4. Size dependent characteristics of mix, coarse and fine fractions of radish powder

The frictional properties comprised of coefficient of friction (COF) and angle of repose (AOR) was found to be the treatment and temperature dependent (Table 2). The static coefficient of friction was found to be highest for the radish powders dehydrated at 50^0C when experimented on transversely oriented plywood. The angle of repose was found as highest for the radish powder obtained without any treatment but dehydrated at 50^0C. The moisture content, structure of the particle and the adhesive force of the particles and that of the studied contact surfaces are the factors which have affected the posed variations in the frictional properties of radish powder obtained at different temperatures (Table 2). As observed leaf powder from blanched leaves exhibit variable degree of cohesiveness and adhesiveness, thus the values of coefficient of friction has reflected the variations for different surfaces [35-36].

L-value of fresh leaf as 60.79 was decreased to 55.10 for unblanched powder and 43.53 for blanched samples when dehydrated at 50^0C. The increase in dehydration temperature has further reduced the lightness values (Table 2). The process of blanching physically make the leaf tissues succulent, which provide the compact mass on dehydration thus it is also evident for the decreased lightness (L) value on blanching treatment (Figure 5). Moreover, destruction of chlorophylase enzyme restricts the change of green colour due to associated changes in chlorophyll. Further, the higher compactness with blanched and dried samples make the product denser as reflected with the increased bulk densities when compared with the untreated samples. The decreased b values may be correlated with the improved greenness or with the loss of brightness as per the corresponding values of b, which supports the findings [37-38].

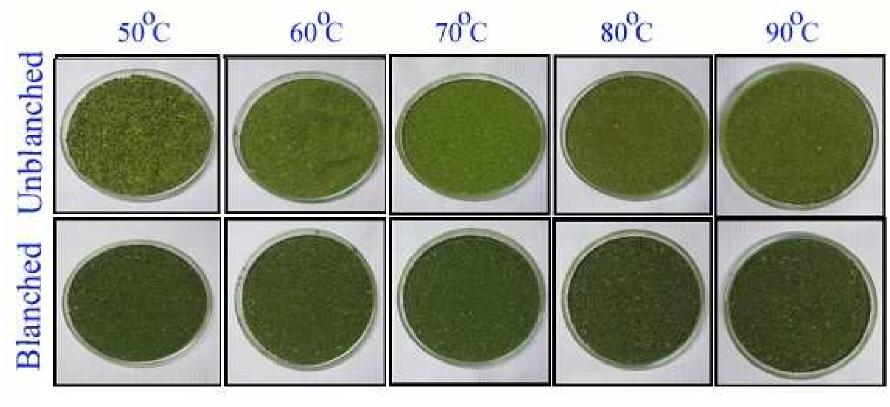

Figure 5. Effect of blanching on the characteristics of radish powder

Chlorophyll content decreased with the increase in dehydration temperature and found the increased chlorophyll content in blanched samples [39]. Carotene is the pigment which is not visible in plant leaves, as chlorophyll masked it entirely [26] and the concentration in carotene in the dehydrated powders also found to be decreased with increasing the dehydration temperature for control as well as the blanched radish leaves. Carotene content found in fresh radish leaves was 3.955 mg/100g [40]. The concentrations of chlorophyll and carotene in dehydrated powders at different temperatures are found to be in agreement with the earlier studies carried out on leafy vegetables [15, 41-42].

Development and Characteristics of Functional Radish Powder

Enormous efforts have been reported to preserve the green color of vegetables employing the techniques of pH control, control of temperature, applications of different salts, modified the atmospheres and the combinations. But combination temperature has not been found in cited literature to arrest the process of chlorophyll conversion till that will be in form of phyllins, the active nutraceuticals. Attempts have been made in the present investigation to maintain the colour of the dehydrated powders with maintaining the phytochemical properties in the combination temperature dehydration process.

Chlorophyll is the derivative of dihydroporphyrin, chelated with centrally located magnesium atom and are ubiquitous in most of the higher plants. It is associated with carotenoids, lipids and lipoproteins and present in the chloroplast of leaves, a photosynthesizing part. Chlorophyll a and b found mostly in the ratio of 3:1 in green parts of the plant systems and differs in carbon C-3 substitution as the presence of methyl and formyl group, respectively [43]. The presence of phytol group esterified to propionate at the carbon C-7 position makes the chlorophyll hydrophobic. The presence of intense phytol peak in the gas chromatogram as verified through mass spectroscopy support the disorganization of chlorophyll membrane array at subjected higher dehydration temperatures of 80^{O}C as initial temperature. As per the attained dehydrating radish leaves attained a temperature at wet bulb temperature lied nearly the temperature required for activation (60 - 82.2^{O}C) of chlorophyllase (chlorophyll chloropyllido - hydrolase, EC 3.1.1.14), and chlorophylidine as phyllin bright green pigment to some extent was formed leaving some of the chlorophyll intact in the leaf cells during the initial phase of dehydration (Prasad and Singh, 2014). As per the properties of reduction of moisture during the process of dehydration in falling rate period the raised temperature and reduced the moisture to a greater extent arrested the mobility of reacting entities and thus arrested the further conversions of chlorophyll during the initial phase. The reduction of dehydration temperature in the finishing phase has possibly maintained in the form of phyllin
The characteristics of radish powder thus obtained by the improved technique at combination temperature of dehydration was subjected to fractionation into course and fine fractions using 60 BSS mesh following the particle size distribution pattern of mixed powder [2]. The powders were analyzed for water absorption capacity, water solubility index(Table 3) with proximate composition, chlorophyll content and anti-oxidant activity as free radical quenching capacity (Table 4). Proteins and crude fiber are found to be in good amount [44]. The moisture content of the powder was found to be 4.03±0.27% with the protein content as around 13% with the higher amount of ash content (Table 4). It

has been found that the leaf proteins are of high quality and being utilized abundantly in different food applications [45]. Water holding capacity synergisms with sweeteners have created a renewed interest in plant fibers for finding the applications in nutraceutical formulations. Studies have been shown the beneficial effects of fiber in protecting cancer and heart diseases, prevention of constipation, normalization of blood lipids, regulation of glucose absorption and insulin secretion [46]. Crude fiber, being important and rich component found to be around 20% in radish powder (Table 4). Appreciable amount of free radical quenching capacity (>325mg per g) and chlorophyll content (>500mg per 100g) further makes this biomaterial as healthier and may be used to make the food functional.

Table 3. Physical properties of radish leaf powder under improved technique

Leaf powder	Bulk density (kg/m^3)	Angle of repose	Coefficient of friction			WAC (g/g)	WSI (%)
			Glass	Steel	Plywood		
Mix	536 ± 5^b	50.94 ± 1.67^a	0.30 ± 0.00^a	0.33 ± 0.00^a	0.58 ± 0.00^a	3.42 ± 0.02^b	29.28 ± 0.97^c
Coarse	491 ± 7^b	49.90 ± 1.21^a	0.28 ± 0.01^b	0.30 ± 0.01^b	0.54 ± 0.00^b	4.65 ± 0.07^a	35.41 ± 0.85^b
Fine	570 ± 9^a	51.88 ± 1.11^a	0.33 ± 0.00^a	0.32 ± 0.01^a	0.58 ± 0.01^a	3.66 ± 0.13^b	49.05 ± 3.75^a

Means in the same column followed by the same letters are not significantly different at $P \leq 0.05$

Table 4. Chemical properties of radish leaf powder under improved technique

Leaf powder	Moisture content, %	Crude Fat, %	Protein, %	Crude fiber, %	Ash, %	Carbohydrate, %	Chlorophyll, mg/100g	Antioxidant, mg/g
Mix	4.03 ± 0.27^b	3.33 ± 0.16^b	13.15 ± 0.99^a	20.63 ± 0.11^b	12.16 ± 0.40^{ab}	46.68 ± 0.37^b	506.90 ± 24.75^b	326.80 ± 4.67^a
Coarse	4.22 ± 0.02^{ab}	3.25 ± 0.06^b	12.75 ± 0.12^a	22.24 ± 0.22^a	12.33 ± 0.41^a	45.47 ± 0.39^c	505.30 ± 6.65^b	326.66 ± 1.89^a
Fine	4.36 ± 0.04^a	3.41 ± 0.02^a	13.23 ± 0.01^a	19.92 ± 0.99^b	11.53 ± 0.33^b	47.54 ± 0.70^a	583.10 ± 4.67^a	329.84 ± 0.27^a

Means in the same column followed by the same letters are not significantly different at $P \leq 0.05$

The phytochemical compounds present in the extracts of radish leaves were identified through GC-MS (Figure 6). The active compounds with their retention time (RT), peak area (%) before and after blanching are presented in Table 5.

Table 5. Phyto chemicals detected from the hexane extract of radish leaf powder

R.Time	Area, %		Name of the compound
	Control	Improved technique	
9.031	4.02	2.60	4-Methylthio-3-butenyl isothiocyanate
10.454	3.96	5.73	2-Methoxy-4-vinylphenol
11.710	0.94	1.75	Nonyl ester
16.554	14.08	14.87	Neophytadiene
16.618	2.40	3.07	3,7,11,15-Tetramethyl-2-hexadecene
16.805	2.35	1.57	1-Octadecyne
17.001	3.61	3.74	1,4-Eicosadiene
19.164	0.98	1.50	Linolenic acid
19.273	7.98	17.11	Phytol
20.727	0.55	1.22	1-Isopropyl-2-methyl-1,2-propanediamine
22.254	1.80	4.61	Benzedrex
22.422	0.61	0.94	1-chloroctadecanol
22.998	1.57	0.97	1,2-benzenedicarboxylic acid
24.169	5.47	9.77	Heptadecyl ester
25.570	2.25	1.00	Squalene
26.161	0.61	1.41	Tetracosane
26.261	2.84	3.65	1-eicosanol
28.734	0.87	1.06	1,2-Hexadecene epox
30.128	6.19	6.65	Vitamin E
32.666	1.13	1.99	Beta.-sitosterol
34.747	4.40	8.34	Campesterol

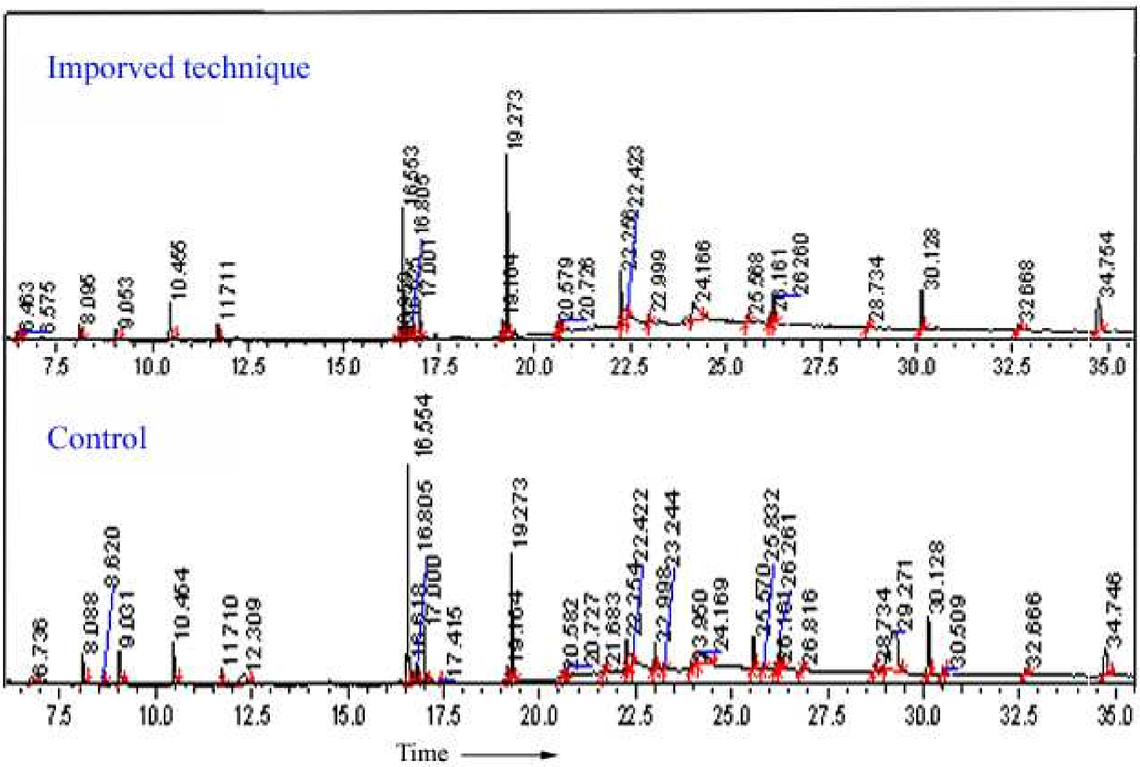

Figure 6. Gas chromatograph in GCMS for the radish leaf powder

Table 6. Phyto chemicals from hexane extract with health benefits

Name of compound	Nature of compound	Activity/Functions
Phytol	Diterpene	Antimicrobial, anticancer, anti-inflammatory, diuretic
Vitamin E acetate	Ester	Antithrombotic
Campesterol	Terpene	Antioxidant, Hypocholesterolemic
Beta.-sitosterol	Steroid	Anticancer, hepato-protective, antimicrobial, antiasthmatic, diuretic

Twenty three compounds were identified in the methanolic extract of basil based leaf shaped starch matrix. The identified twenty one compounds present in the leaf were. 4-Methylthio-3-butenyl isothiocyanate, 2-Methoxy-4-vinylphenol, Nonyl ester, Neophytadiene, 3,7,11,15-Tetramethyl-2-hexadecene, 1-Octadecyne, 1,4-Eicosadiene, Linolenic acid, Phytol, 1-Isopropyl-2-methyl-1,2-propanediamine, Benzedrex , 1-chloroctadecanol, 1,2-benzenedicarboxylic acid, Heptadecyl ester, Squalene , Tetracosane, 1-eicosanol , 1,2-Hexadecene epox, Vitamin E , Beta.-sitosterol and Campesterol. The increase in the peak and concentration of phytol reflects and support the hypothesis for the conversion of chlophyll to phyllins through enzymatic pathway (Figure 6). The identified compounds belongs to the class of alkaloids, organic acids, phenolics, esters, terpenes, steroids and sulfur containing compounds of pharmaceutical importance presented in Table 6 [47-48]. The presences of various bioactive compounds further confirm the applicability of radish leaf powder for various ailments.

CONCLUSION

Physical, chemical and optical properties of radish leaf powder are treatment and temperature dependent. Blanching of radish leaf prior to dehydration results into a powder of compact structure while the untreated radish leaf under developed process of combination temperature dehydration into more porous structures. *Raphapus sativus* leaf powder as obtained under the combination dehydration temperature of 80°C as initial and 70°C as finishing temperature without any additional treatment give a powder of higher quality, which may further improves on fractionation. The fine fraction may be considered as functional material to be used to make the food rich with therapeutic values.

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