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Studies on effects of cabinet dying on functional and phyto-chemical quality of green leafy vegetables powder

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Abstract
Present work have been undertaken to study the effects of cabinet drying on functional, re-constitutional and phyto-chemical qualities of dried green leafy vegetables powder *Viz*. fenugreek, amaranth, roselle and mixed green leafy vegetables powder. The green leafy vegetables are neglected but best source of antioxidant, polyphenols, flavonids etc. The chemically blanched leaves of respective vegetables get dried in cabinet drier and grinded to obtain fine powder. The highest water holding capacity of roselle leaves powder (11.85 g/g). dried amaranth powder was significantly superior over dried roselle leaves powder and at par with fenugreek leaves powder with respect to oil absorption capacity. The dried roselle leaves powder found significantly superior than dried fenugreek leaves powder and amaranth leaves powder with respect to swelling capacity. The dried amaranth leaves powder had maximum solubility and dispersibility i.e. 83.00 and 61.26 percent respectively. The good wettability was observed in fenugreek powder i.e. 280 seconds. The fresh amaranth leaves showed higher antioxidant activity than fresh fenugreek leaves. It was observed that drying of green leafy vegetables results in decreasing the contents of total polyphenol, flavonoids and alkaloids. It was concluded that drying of the green leafy vegetables results in improving the functional, re-constitutional and phyto-chemical quality characteristics of dried green leafy vegetables powder.

Keywords: Functional properties, re-constitutional properties, total alkaloids, total flavonoids and total phenol

1. Introduction
Trigonella foenum-graecum L. is also called as fenugreek, which is leguminous crop and native to the Indian subcontinent and the Eastern Mediterranean region (Petropoulos, 2002) [20] It is currently widely cultivated in central Asia, central Europe, northern Africa, North America and parts of Australia, with India being the leading fenugreek producer in the world (Fotopoulos, 2002) [7].

Amaranth (*Amaranthus hypochondriacus*, *A. tricolor*) is an herbaceous annual with upright growth habit, cultivated for both its seeds which are used as a grain and its leaves which are used as a vegetable or green. Amaranth leaves contains moisture, protein, fat, total carbohydrate, fiber, calories, phosphorous, iron, potassium, vitamin A, riboflavin, niacin, vitamin C, thiamine, ash and calcium about 86.9 g, 3.5 g, 0.5 g, 6.5 g, 1.3 g, 36 kcal, 67 mg, 3.9 mg, 411 mg, 6100 IU, 0.16 mg, 1.4 mg, 80 mg, 0.08 mg and 2.6 g. per 100 g respectively. (Brien and Price, 2008) [3].

Roselle (*Hibiscus sabdariffa* L.) is popularly recognized as 'mesta' or 'chukur' in Indian subcontinent including Bangladesh (Halimatul *et al*. 2007; Rao 2008) [8, 22]. It is widely cultivated in Tropical Africa, Sudan, Egypt, Ethiopia, Mali, Nigeria, Chad, India, Indonesia, the Phillipines, Malaysia, Brazil, Australia, Mexico, Hawai and Florida of USA. Roselle is a miracle plant with various utilizations (Crane 1949) [5]. The leaves and calyx are used as vegetable in many countries of the tropics. Generally roselle is considered as traditional medicine for the remedy of diuretic, mild laxative, cancer, cardiac and nerve diseases.

Green leafy vegetables (GLVs) occupy an important place among the food crops, as these provide adequate amounts of many vitamins and minerals for humans. They are rich source of carotenoids, ascorbic acid, riboflavin, folic acid and minerals like calcium, iron and phosphorus. In nature, there are many underutilized greens of promising nutritive value, which can nourish the ever-increasing human population.

Being the highly perishable food commodities drying of green leafy vegetable is one of the oldest and cheap methods to extend the shelf life. The cabinet drying resulted in reducing the moisture content to acceptable stage and reduces bulk volume of storage. The dried GLV get grinded to fine powder. The dried green leafy vegetables powder possess got antioxidant,

functional, re-constitutional and phyto-chemical properties. Based on reviewed literature the present investigation was formulated to study the impact of drying on phyto-chemical and functional properties of dried green leafy vegetables.

2. Material and Method

2.1 Material

2.1.1 Raw material

The green colored green leafy vegetables i.e. fenugreek, amaranth and roselle were collected from local market of Parbhani, Maharashtra.

2.1.2 Chemicals

All the chemicals, organic solvents and acids used were of analytical grade. Chemicals required for processing of raw materials, preparation and analysis of formulated products were obtained from Department of Food Engineering, College of Food Technology, V.N.M.K.V, Parbhani, Maharashtra, India.

2.2 Methods

2.2.1 Functional properties of green leafy vegetable powder

i. Water Holding Capacity

Water Holding Capacity was calculated using the Sowbhagya *et al*., (2007) [25] test. Weighed 1 g of the material in a graduated test tube and added 30 ml of distilled water. The material was permitted to hydrate at normal temperatures for 18 hours, then filtered via filter paper Whatman No.1. The weight of the hydrated residue was estimated and a constant weight was dried at 105 ± 2 ^{0}C. The outcomes were presented as gm of water hold/gm of dry sample.

$$\text{Water Holding Capacity (g/g)} = \frac{\text{Residual hydrated weight} - \text{Residue dry weight}}{\text{Residual dry weight}}$$

ii. Oil Absorption Capacity (OAC)

The capacity of oil absorption was calculated as illustrated by Sangnark and Noomhorm (2004) [23] and was represented as gram of oil per gram of powder retained. Weighed sample (1 g) into a pre-weighed centrifuge tube (W1) and noted weight (W2), to which 25 ml of groundnut oil was introduced and stirred. The contents were permitted to stand at ambient temperature for 18 hours, centrifuged (4000 rpm, 20 min) and decanted the supernatant and kept the tubes in a slant position to remove excess oil. Tube weight was reported (W3). The variation in the weight of the dry-sampled centrifuged tubes and after oil binding, provides the quantity of fat consumed. The findings were expressed in gm of bound oil/ gm of sample.

Oil Absorption Capacity (g/g) = Initial wt. of sample – Final wt. of sample after oil uptake

iii. Swelling Capacity

The capacity to swell has been assessed as defined by Sowbhagya *et al*., (2007) [25]. Sample (1 g) was put in a graduated test tube and the marked volume (V1) was set. 30 ml of distilled water was then introduced and the contents were dehydrated for 18 hrs. The final volume of the sample reached was measured (V2). The outcome was represented as ml of swollen sample per gm of dry sample initial.

Swelling Capacity (ml/g) = Initial volume - Final volume

2.2.2 Re-constitutional properties of green leafy vegetable powder

i. Solubility

One gram of powder was ground in a hand blender and combined with 100 mL of distilled water. The solution has been shifted to 50 mL centrifuge tubes and centrrifuged for 5 min at 3000 rpm. It was permitted to settle for 30 minutes and shifted 25 mL of the supernatant to pre-weighed petri plates that were dried for 5 hr. at 105 ^{0}C. The solubility percentage was measured as the difference in weight.

ii. Dispersibility

Distilled water was taken in a 50 ml beaker (10 mL at 25 ^{0}C) and 1 g of sample was added. The sample was intensely agitated for 15 s making 25 maximum movements back and forth around the beaker's whole diameter. The reconstituted powder was pumped into a pre-weighted aluminum pan through a 212 micron sieve. The sieved pan with sample was dried for 4 h at a temperature of 105 ^{0}C. The dispersibility was determined according to the Jinapong *et al*., (2008) [10] method,

$$\text{Dispersibility (\%)} = \frac{(10 + a) \times \%\,TS}{a \times (10 - b) / 100}$$

where, a - amount of powder (g) taken
b - moisture content in the powder and
%TS - dry matter in percentage in the reconstituted powder after it has been passed through the sieve

iii. Wettability

Sample wettability was measured using the process defined in Jinapong *et al*., (2008) [10]. Wettability is the period needed for 1 g of powder accumulated on the liquid surface to totally submerge at a temperature of 25 ^{0}C in 400 mL distilled water.

2.2.3 Determination of phytochemicals

2.2.3a Qualitative determination of phytochemicals

Preparation of the plant extracts

To eliminate the surface contaminants, the leaves were washed under running tap water and the leaves were dried. Samples of the powdered leaf were assigned to successive extraction using soxhlet apparatus with chloroform, methanol, and acetone. The fresh leaf material was ground and filtered using distilled water and used as an aqueous extract. The extracts obtained using solvents were concentrated using rotary vacuum evaporator and then dried. For phytochemical analyzes used the obtained extract.

2.2.3b Quantitative determination of phytochemicals

i. Alkaloid

Five grams of the sample was measured into a 250 ml beaker and 200 ml of 10 percent acetic acid was introduced to ethanol and left to stand for 4 minutes, this was filtered and extract concentrated to one quarter of the original volume in a water bath. When the precipitation was finished, condensed ammonium hydroxide added drop wise to the extract. The whole solution was permitted to settle and the precipitate was collected, washed and purified with dilute ammonium hydroxide. The residue was alkaloids which was dried and weighted (Harbone, 1973) [9].

$$\text{Alkaloid (\%)} = \frac{W_3 - W_2}{W_1} \times 100$$

Where,
W_1 = Initial weight of sample,
W_2 = Weight of the extract and
W_3 = Final weight of the residue

2.2.4 Determination of total phenolic and total flavonoid content

2.2.4a Preparation of cold and hot percolations

In triplicates, fifty grams (50 g) of green leafy vegetables were packed into brown envelopes and drying to constant weight at a temperature of 65 ^{0}C. The crispy leaves were homogenized into flour by utilizing mortar and pestle. Using cold (30 ^{0}C) percolation temperature, a 0.7 g of powder from each sample was added separately to 25 ml of double distilled deionized water and held with constant shaking at this temperature for 4 hr. For hot (60 ^{0}C) percolation the same process was adopted and extracts were filtered. Another 25 ml of deionized double distilled water was added to the mark and the method of extraction was repeated. The filtrates were pooled to give a minimum extract of 50 ml for each sample

i. Determination of total phenolic content

Total phenolic content (TPC) was quantified from the extracts using the Folin – Ciocalteu process (Pinelo *et al*., 2005). Firstly 5 ml Folin -Ciocalteu reagent has been introduced to 1 ml sample tube. Then added to the mixture 4 ml of 7.5 per cent (w / v) sodium carbonate. After 60 min of room temperature incubation (32±1 ^{0}C) the absorbance was read against blank sample at 765 nm. The findings were presented as an equal mg of gallic acid per gram of fresh sample on dry weight basis (mg GAE / g dw base). For all samples the overall phenolic content was determined using the formula,

$C = c\ V/m$
where, C = total phenolic content mg GAE/g dry extract
c = concentration of gallic acid obtained from calibration curve in mg/mL
V = volume of extract in ml
m = mass of extract in gram.

ii. Determination of total flavonoid content

The total flavonoids content of cold and hot extracts was estimated using a slightly modified method stated by Meda *et al*., (2005) [17]. A 0.5 ml of reasonably diluted sample was blended with 0.5 ml methanol, 50 µl 10% $AlCl_3$, 50 µl of 1 mol L^{-1} potassium acetate and 1.4 ml water and enabled to incubate for 30 min at room temperature. Afterwards the reaction mixture absorbance was measured at 415 nm. The total flavonoid was determined using formula quercetin as standard,

$$TFC = \frac{A \times DF}{A^{1\%}{}_{1cm} \times (w - ld)}$$

Where,
A = Absorbance
DF = Dilution Factor
$A^{1\%}{}_{1cm}$ = Specific absorption by $AlCl_3$
w = Mass of plant material
ld = Loss on drying

2.2.5 Determination of antioxidant activity

2.2.5a Preparation of extract

The extracts were prepared as usual way; 2 gm of plant material was used for assaying antioxidant activity. The decoction was formulated by 3 minutes of placement of the plant material in 100 ml of boiling distilled water. The infusion had been made by steeping the plant content for 30 minutes in freshly boiling distilled water. The extracts were cooled, purified and with distilled water, the concentration was raised to 100 ml (Toda, 2011) [26].

2.2.5b Antioxidant Activity Assay

Di phenyl picryl hydrazyl (DPPH) assay according to Zaeoung *et al*., (2005) [28] was used to test the antioxidant activity of the extracts. 2 millilitres of 100 µM DPPH solution in absolute ethanol was added into 2 ml of extract and mixed well. The samples were permitted to react with DPPH for 20 minutes and the absorbance was calculated at 520 nm (Lab Spectronic) after the reaction was complete. Ascorbic acid was used as a supportive indicator (1 percent in fresh water) while distilled water was used as blank for all samples. Antioxidant activity was described as percent radical inhibition of DPPH and observed from dark violet to a lighter tone or colourless solution by decolorizing the DPPH reagent. In the DPPH radical scavenging test, antioxidants react with DPPH and transform it to the yellow coloured a-diphenyl-β-picryl hydrazine. The degree of discolouration shows the sample's potential for radical-scavenging.

$$\text{DPPH scavenging activity (\%)} = \frac{\text{Absorbance of DPPH blank} - \text{Absorbance of sample}}{\text{Absorbance of DPPH blank}} \times 100$$

3. Results and Discussion

3.1 Functional properties of blanched green leafy vegetables powder

The observations of functional properties of green leafy vegetable powders were presented in Table 1.

Table 1: Functional properties of green leafy vegetables powder

GLV	WHC (g/g)	OAC (g/g)	Swelling capacity (ml/g)
Fenugreek	11.64	4.2	3.29
Amaranth	10.12	4.3	2.73
Roselle	11.85	3.7	3.96
Mixed GLV	11.16	4.0	3.42
SE±	0.233	0.1902	0.3052
CD at 5%	0.8063	0.6582	1.0562

*Each value is average of three determinations
WHC = Water holding capacity
OAC = Oil Absorption capacity

The data presented in table 1 showed the highest water holding capacity of roselle leaves powder (11.85 g/g), while it found decreased in case of fenugreek leaves powder (11.64 g/g) and amaranth leaves powder (10.12 g/g). The water holding capacity of mixed green leafy vegetable powder was 11.16 g/g. It might be due to greater water loving tendency than water hating tendency. On the other hand, Kuntz (1971) [13] given that lower water absorption capacity is due to low availability of polar amino acids.

The result shows that dried amaranth powder was significantly superior over dried roselle leaves powder and at par with fenugreek leaves powder with respect to oil absorption capacity. The highest oil absorption capacity was found in dried amaranth powder i.e. 4.3g/g followed by fenugreek powder and roselle powder 4.2 and 3.7g/g

respectively. The oil absorption capacity of mixed green leafy vegetable powder was 4 g/g.The high oil absorption capacity also makes the flours feasible in increasing in flavour and mouth feel when used in food production (Appiah *et al*., 2011) [2].

The dried roselle leaves powder found significantly superior than dried fenugreek leaves powder and amaranth leaves powder with respect to swelling capacity. It was found that swelling capacity of dried roselle leaves powder (3.96 ml/g) was highest followed by dried fenugreek leaves (3.29 ml/g) and amaranth leaves powder (2.73 ml/g). The swelling capacity of mixed green leafy vegetable powder was 3.42 ml/g. Similar trend was also observed by Makanjuola and Adebola (2017) [6], the corn sample produced by using cabinet drying obtained maximum swelling capacity than sun and oven drying due to their ability of the equipment to reduce nutrients losses most effectively the starch particles during processing.

3.2 Re-constitutional properties of green leafy vegetables powder

The data related to re-constitutional properties of dried green leafy vegetable powder were taulated in Table 2.

Table 2: Re-constitutional properties of green leafy vegetables powder

GLV	Solubility (%)	Dispersability (%)	Wettability (sec)
Fenugreek	80	57.12	280
Amaranth	83	61.26	264
Roselle	76	55.98	312
Mixed GLV	81	59.87	285
SE±	0.819	0.597	4.2874
CD at 5%	2.842	1.871	13.7152

*Each value is average of three determinations

The data presented in table 2 revealed that the effects of cabinet drying on re-constitutional properties of green leafy vegetable powder. The dried amaranth leaves powder had maximum solubility i.e. 83 percent followed by fenugreek leaves powder and roselle leaves powder i.e. 80 and 76 percent respectively. The solubility of mixed green leafy vegetable powder was 81 percent. Many factors that impact water solubility of green leafy vegetables powder including processing conditions, chemical composition, particle size, density, pH and storage conditions (Mirhosseini and Amid, 2013) [18]. The dried amaranth leaves powder found significantly superior than dried roselle powder and at par with fenugreek leaves powder with respect to solubility. Similar trend was also observed by Mahendran (2010) [15] who found that solubility of freeze dried and tunnel dried fruit juice concentrate was 96.2 and 86.3 percent, which showed it was decreased with increase in temperature.

The dried amaranth leaves powder found significantly superior than dried roselle leaves powder and at par with dried fenugreek leaves powder with respect to dispersability. The dispersability of dried amaranth powder (61.26 percent), was found to be higher than dried fenugreek leaves powder (57.12 percent), dried roselle leaves powder (55.98 percent) and mixed green leafy vegetable powder (59.87 percent). Kim and Bhowmik (1990) [12] stated that the wettability and dispersability of powdered material depend on particle size, density, porosity, surface area, surface charge and surface activity of the particles.

The wettability of dried fenugreek, amaranth, roselle and mixed green leafy vegetable powder was 280, 262, 312 and 285 sec. respectively. The wettability of powder was increased with increase in drying condition with respect to temperature. The results are comparable with the findings of Sarangam and Chakraborty (2015) [24], who found that, wettability of sun dried and cabinet dried amla juice powder was 194 and 230 secnds and also found that wettability was increased with increased in temperature during drying.

3.3 Phytochemical constituents of green leafy vegetables

Phytochemicals showed their health protective properties in different ways. Studies on phytoconstituents of green leafy vegetables documented the presence of alkaloids, flavonoids, and poly phenols. In the present study phytonutrients are quantitatively analyzed in fresh and dried GLV and results are presented in Table 3.

Table 3: Effects of cabinet drying on phyto-chemical constituents of green leafy vegetables

Samples	Total phenol (µg/ml)		Total flavonoids (µg/ml)		Total alkaloids (%)	
	Fresh	Dried	Fresh	Dried	Fresh	Dried
Fenugreek	81.32	76.94	738.10	733.94	11.93	11.58
Amaranth	15.10	12.85	409.06	406.89	3.14	2.76
Roselle	44.86	42.76	417.25	415.61	26.24	25.80
Mixed GLV	46.09	44.25	520.10	518.90	14.02	13.36

*Each value is average of three determinations

The data presented in table 3 showed the effects of drying on phyto-chemical constituents of green leafy vegetables. It was observed that total phenol present in fresh fenugreek leaves was 81.32µg/ml which was reduced after drying. The total poly phenol retain after drying in dried fenugreek leaves was 76.94 µg/ml. The total poly phenol contents of fresh and dried amaranth leaves were 15.10 and 12.85 µg/ml respectively. The total poly phenol contents of fresh and dried roselle leaves were 44.86 and 42.76 µg/ml respectively. The total poly phenol contents of fresh and dried mixed GLV were 46.09 and 44.25 µg/ml respectively.

Cabinet drying at 60 ^{0}C temperature was shown to gradually inactivate polyphenol oxidases enzyme present in green leafy vegetables, however, some of their initial activities may have previously occurred and disintegrate some polyphenols (Lim and Murtijaya, 2007) [14].

The total flavonoids contents of fresh fenugreek leaves were 738.10 µg/ml which was reduced to 733.94 µg/ml after drying. The total flavonoids contents of fresh amaranth leaves were 409.06 µg/ml which was reduced to 406.89 µg/ml after drying. The total flavonoids contents of fresh roselle leaves were 417.25 µg/ml which was reduced to 415.61 µg/ml after drying. The total flavonoids contents of fresh mixed GLV were 520.10 µg/ml which was reduced to 518.90 µg/ml after drying. The reduction in flavonoid might be due to drying time and temperature. Heating may breakdown phyto-chemicals which impact integrity of cell wall and cause a migration of some flavonoids component. In addition, the loss

in flavonoids may due to degradation by chemical reactions which oxygen, enzymes and light (Davey *et al*., 2000) [6].
The alkaloid present in fresh fenugreek leaves was 11.93 percent which get reduced on drying to 11.58 percent. The alkaloid present in fresh amaranth leaves was 3.14 percent which get reduced on drying to 2.76 percent. The alkaloid present in fresh roselle leaves was 26.24 percent which get reduced on drying to 25.80 percent. The alkaloid present in fresh mixed GLV was 14.02 percent which get reduced on drying to 13.36 percent.

3.4 Effect of drying on antioxidant activity of green leafy vegetables

The effect of cabinet drying on antioxidant activity of green leafy vegetables were evaluated and summarized in Table 4.

Table 4: Effect of cabinet drying on antioxidant activity of green leafy vegetables

Drying method	Antioxidant activity (mg/ml)	
	Fresh	After drying
Fenugreek leaves	2.48	1.73
Amaranth leaves	5.10	4.25
Roselle leaves	25.63	23.58
Mixed GLV	----	9.85
SE±	0.832	0.789
CD at 5%	2.583	2.432

The data presented in table 4 showed the effects of cabinet drying on antioxidant activity of green leafy vegetables. The DPPH (diphenyl picryl hydrazyl) of dried green leafy vegetables was significantly affected by temperature of drying. The DPPH radical scavenging assay is an easy, rapid and accurate way to quantify the antioxidant activity in green leafy vegetables extracts. extract was prepared by placing the powder in boiling water for 3 min. It was observed that the antioxidant activity of fresh fenugreek leaves was 2.48 mg/ml where as it was decreased for dried fenugreek leaves i.e. 1.73 mg/ml. It was clear that the antioxidant activity was decreased with increase in temperature of drying. The similar results were obtained by research finding of Vani and Gupta (2014) [27].
The fresh amaranth leaves showed higher antioxidant activity than fresh fenugreek leaves. The antioxidant activity of fresh amaranth leaves was 5.10 mg/ml. The antioxidant activity was decreased after drying. The antioxidant activity of dried amaranth leaves was 4.25 mg/ml. The similar results were obtained by Karama *et al*. (2019) [11]. The roselle leaves possessed the highest antioxidant activity. The antioxidant activity of fresh and dried roselle leaves were 25.63 mg/ml and 23.58 mg/ml respectively. The similar results were obtained by Norhaizan *et al*. (2010) [19]. The antioxidant activity of dried and mixed green leafy vegetables was 9.85 mg/ml.
The antioxidant activity was attributed to the amount of phenolic compounds and flavonoid present in dried green leafy vegetables. Natural antioxidants increase the antioxidant capacity. Aldosari (2014) [1] observed freeze dried apple pomace contained maximum antioxidant activity as exhibited by ORAC and DPPH results, 350.27 and 278.8 µmol TE/g, respectively.

4. Conclusion

Thus in light of scientific data of the present investigation, it may be concluded that drying of the green leafy vegetables results in improving the functional, re-constitutional and phyto-chemical quality characteristics of dried green leafy vegetables powder.

5. References

1. Aldosari MT. Effects of different drying methods on the total phenolics, antioxidant properties and functional properties of apple pomace. Master of Science (Food Science) – Thesis, 2014. Retrieved from https://d.lib.msu.edu/etd/2743/datastream/OBJ/download/Effects_of_different_drying_methods_on_the_total_phenolics_antioxidant_properties__and_functional_properties_of_apple_pomace.pdf.
2. Appiah F, Asibuo JY, Kumah P. Physicochemical and functional properties of bean flours of three cowpeas (*Vigna unguiculata* L. Walp) varieties in Ghana. African Journal of Food Science, 2011; 5(2):100-104.
3. Brien GK, Price M. Amaranth grain and vegetable types. 2008, 04.
4. Carr RL. Evaluating flow properties of solids. Chemical Engineering. 1965; 72:163-168.
5. Crane JC. Roselle-a potentially important plant fiber. Economic Botany. 1949; 3(1):89-103.
6. Davey MW, Van Montagu M, Inzé D, Sanmartin M, Kanellis A, Smirnoff N. Plant L-ascorbic acid: chemistry, function, metabolism, bioavailability and effects of processing. Journal of the Science of Food and Agriculture. 2000; 80(7):825-860.
7. Fotopoulos C. Marketing in: GA. Petropoulos (Ed.). Fenugreek - The genus *Trigonella*, Taylor and Francis, London and New York. 2002, 183-195.
8. Halimatul SMN, Amin I, Esa MN, Nawalyah AG, Muskinah M.Protein quality of Roselle (*Hibiscus sabdariffa* L.) seeds. Asian Food Journal. 2007; 14(2):131-40.
9. Harbone JB. Phytochemical Methods, A guide to modern techniques of plant analysis, 3 Ed^{n}. Chapman and Hall Int. Ed^{n}, New York, 1973.
10. Jinapong N, Suphantharika M, Jamnong P. Production of instant soy milk powders by ultrafiltration, spray drying and fluidized bed agglomeration. Journal of Food Engineering. 2008; 84:194-205.
11. Karama C, Francesco G, Erica L, Giorgia M, Michał A, Ryszard A *et al*. Antioxidant activity and phenolic composition of amaranth (*Amaranthus caudatus*) during plant growth. Antioxidant. 2019; 8(173):01-14.
12. Kim SS, Bhowmik SR. Survival of lactic acid bacteria during spray drying of plain yogurt. Journal of Food Science. 1990; 55:1008-1010.
13. Kuntz ID. Hydration of macromolecules, III. Hydration of polypeptides. Journal of the American Chemical Society. 1971; 93:514-516.
14. Lim YY, Murtijaya J. Antioxidant properties of *Phyllanthus amarus* extracts as affected by different drying methods. LWT-Food Science and Technology. 2007; 40(9):1664-1669.
15. Mahendran T. Physico-chemical properties and sensory characteristics of dehydrated guava concentrate: effect of drying method and maltodextrin concentration. Tropical Agricultural Research and Extension. 2010; 13(2):48-54.
16. Makanjuola OM, Adebola A. Effect of Dehydration Methods of the Proximate Composition, Mineral Content and Functional Properties of Starch Flour Extracted from Maize. 19th International Conference on Food Processing Systems and Technology, Singapore, SG. (November 09-10, 2017), 2017.

17. Meda A, Lamien CE, Romito M, Millogo J, Nacoulma OG. Determination of the total phenolic, flavonoid and proline contents in Burkina Fasan honey, as well as their radical scavenging activity. Food Chemistry. 2005; 91:571-577.
18. Mirhosseini H, Amid BT. Effect of different drying techniques on flowability characteristics and chemical properties of natural carbohydrate-protein gum from durian fruit seed. Mirhosseini and Amid Chemistry Central Journal. 2013; 7(1):1-14.
19. Norhaizan M, Fong SH, Amin I, Chew LY. Antioxidant activity in different parts of roselle (*Hibiscus sabdariffa* L.) extracts and potential exploitation of the seeds. Food Chemistry. 2010; 122(1):1055-1060.
20. Petropoulos GA. Fenugreek - The genus Trigonella, Taylor and Francis, London and New York. 2002, 255.
21. Pinelo M, Rubilar M, Jerez M, Sineiro J, Nunez MJ. Effect of solvent, temperature, and solvent-to solid ratio on the total phenolic content and antiradical activity of extracts from different components of grape pomace. Journal of Agricultural and Food Chemistry. 2005; 53(6):2111-2117.
22. Rao PU. Nutrient composition and biological evaluation of mesta (Hibiscus sabdariffa) seeds. Plant Foods Human Nutrition. 2008; 49(1):27-34.
23. Sangnark A, Noomhorm A. Chemical, physical and baking properties of dietary fibre prepared from rice straw. Food Research International. 2004; 37:66-74.
24. Sarangam S, Chakraborty P. Comparative studies on quality analysis of freeze dried and cross flow dried amla powder. International Journal of Research in Engineering and Technology. 2015; 4(4):620-624.
25. Sowbhagya HB, Florence-Suma P, Mahadevamma S, Taranathan RN. Spent residue from cumin - a potential source of dietary fibre. Food Chemistry. 2007; 104:1220-1225.
26. Toda S. Polyphenol content and antioxidant effects in herb teas. Chinese Medicine. 2011; 2:29-31.
27. Vani P, Gupta RK. Nutraceutical potential of methi (*Trigonella foenumgraecum* L.) and kasuri methi (*Trigonella corniculata* L.). Journal of Pharmacognosy and Phytochemistry. 2014; 3(4):47-57.
28. Zaeoung S, Plubrukarn A, Keawpradub N. Cytotoxic and free-radical scavenging activities of *zingiberaceous* rhizomes. *Songklanakarin* Journal of Science and Technology. 2005; 27:799-812.