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Studies on impact of comparative quality evaluation of sun and cabinet drying on chemical quality characteristics of bitter gourd (*Momordica charantia*)

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Abstract
Present work have been undertaken to study the impact of different drying techniques on chemical qualities of dried bitter gourd (*Momordica charantia*). *Momordica charantia* Linn. (Bitter gourd) commonly known as bitter melon or bitter gourd is tropical and subtropical climber of the family Cucurbitaceae. Bitter gourd are known for its anti-diabetic, anti-fungal, anti-carcinogenic etc properties which contribute limitless numbers of benefits to human being. In present investigation the fresh bitter gourds were cleaned, cut and dried by sun drying and cabinet drying. The dried bitter gourd was analyzed for proximate, mineral and color characteristics. It was observed that the bitter gourd processed by cabinet drying was observed significantly superior over sun drying with respect to fat, protein, fiber and ash contents. The bitter gourd dried by cabinet drying was found significantly superior over sun drying with respect to calcium, phosphorus, magnesium, iron total chlorophyll and total carotene content. From the research it was concluded that the drying of bitter gourd resulted in concentration of nutrients. The cabinet drying method was found significantly superior over sun drying method with respect to chemical composition.

Keywords: Bitter gourd, mineral composition, proximate composition, total carotene and total chlorophyll

1. Introduction
Momordica charantia Linn. (Bitter gourd) commonly known as Bitter melon or Bitter gourd is tropical and subtropical climber of the family Cucurbitaceae. It is widely distributed in China, Malaysia, India and tropical Africa. The Latin name *Momordica* means "to bite" (referring to the jagged edges of the leaf, which appear as if they have been bitten). According to Taylor (2002) [25] all parts of the plant, including the fruit taste very bitter, as it contains a bitter compound called momordicin that is believed to have a stomachic effect. In Ayurveda, various parts of *Momordica charantia* (Bitter gourd) are recommended for many diseases like; cholera, bronchitis, anemia, blood diseases, ulcer, diarrhea, dysentery, sexual tonic and as a cure for gonorrhea.
Bitter gourd contains an array of biologically active plant chemicals including triterpens, proteins, steroids, alkaloids, saponins, flavonoids and acids due to which plant possesses anti-fungal, anti-bacterial, anti-parasitic, anti-viral, anti-fertility, anti-tumorous, hypoglycemic and anti-carcinogenic properties (Grovar and Yadav, 2004) [8]. Fruits are used as traditional medication to cure various diseases like: rheumatism, gout, worms, colic, disease of liver and spleen (Nizamuddin and Naqvi, 1984) [15]. It is also found useful in the treatment of cancer and diabetes (Duke, 1985) [6]. Agarwal and Kamal (2004) [3] stated that bitter gourd had potent hypoglycemic agent due to alkaloids and insulin like peptides and a mixture of steroidal sapogenins known as charantin.
The fruits of bitter melon are utilized as vegetable where as the whole plant parts like, fruits, leaves, roots and seeds of bitter melon as medicine. *Momordica charantia* Linn. (Bitter gourd), a vegetable/ medicinal plant is used in the Ayurvedic system of medicine for treating various diseases including diabetes mellitus, measles, fever, hepatitis, itch etc.

Bitter gourd contains about 90% of moisture and so it is perishable in nature. The seasonality and regional abundances along with perishability are the compelling reasons for its preservation. Among the various methods of food preservation dehydration, pickling and canning are some of the methods that are widely used for bitter gourd. Preservation of foods by means of dehydration is one of the oldest methods and used on large scale from the time immemorial. There are various methods to dry the agricultural produce. In developing countries like India, drying is carried out mostly by conventional open sun drying, which varies with geographical locations and variety of crops. This is uncontrolled process and leads to product contamination, quality loss by virtue of direct exposure to sun light and spoilage due to insects and birds. The introduction of solar cabinet dryers for agricultural produce seems to be a way to lower mass losses and improves the quality of the product considerably. A properly designed solar cabinet dryer can alleviate the drawbacks associated with open sun drying and the quality of the dried product can be improved. It, in turn, gives high returns to the farmers and also couples with rising prices and shortage of conventional fuels. By considering all the facts related to nutritional quality and perishable nature of bitter gourd, present investigation was designed to study the impact of different drying methods on nutritional, mineral and color characteristics of bitter gourd.

2. Material and Methods

2.1 Processing technology for preparation of dried bitter gourd

Fresh, disease free and sound quality bitter gourd were selected. The fresh bitter gourd were washed with clean water and subjected to the treatments like cutting followed by drying. The dried bitter gourds were passed through grinder to make fine powder, which was then packed and stored. (Lonkar *et al*., 2013) [12].

2.1.1 Sun Drying

The bitter gourd was placed in a tray one layer deep on a table. Air was allowed to circulate below as well as above the leaves to speed up drying time. The pieces of bitter gourd in the tray on the table were placed in direct sun and turned occasionally. These pieces of bitter gourd were placed in direct sun for several hrs and the weight of the dried bitter gourd was being measured at intervals of 1 hr until the weight became constant.

Selection of bitter gourd
↓
Washing/Cleaning
↓
Pre-treatments (Cutting)
↓
Sun drying
↓
Grinding
↓
Sieving
↓
Packaging and storage

Flow sheet 1: Drying of bitter gourd by sun drying method

2.1.2 Cabinet drying

Cabinet drying was carried out in the Department of Food Engineering, College of Food Technology, VNMKV, Parbhnai. It consists of a 0.8 kW axial flow fan blowing at air velocity of 3.5 m/s over the heating elements into a drying chamber with perforated trays. The dryer casing is lagged with cushion to give it a compact look. A door was provided to suite the design for loading and unloading the dryer. The pieces of bitter gourd were spread on the tray and placed into the cabinet tray drier at 45^0C temperature and the weight was being measured at interval of 30 min until a constant weight was being recorded.

Selection of bitter gourd
↓
Washing/Cleaning
↓
Pre-treatments (Cutting)
↓
Cabinet drying
↓
Grinding
↓
Sieving
↓
Packaging and storage

Flow sheet 2: Drying of bitter gourd by cabinet drying method

3.2 Proximate composition of bitter gourd

Bitter gourd examined for proximate composition including moisture, fat, protein, carbohydrate, fiber and ash content were determined.

a. Determination of moisture content of bitter gourd

Moisture content was determined by accurately weighing the 5 g of ground sample, and then subjected to drying at 105 ^{0}C for 4 hr in hot air drier. After completion of drying process it was kept in desiccators for cooling. Weighed the cooled sample and calculate the moisture contents. The loss in weight of sample is regarded as moisture contents of the sample. The moisture content of the sample was calculated by formula given by (AOAC, 1990) [1].

$$\text{Moisture (\%)} = \frac{\text{Initial weight} - \text{final weight}}{\text{Total weight of sample}} \text{ X } 100$$

b. Determination of fat content of bitter gourd

5g pulverized and moisture free sample weighed property in thimble and fat is removed with non polar organic solvents like petroleum ether or acetone or hexane etc. in Soxhlet apparatus for period of about 6 to 8 hrs at 60 ^{0}C. Hexane is most commonly used food grade solvent. After completion of the siphoning procedure the excess of solvent removed by evaporation under drier and lipid percentage was calculated (AOAC, 1990) [1].

$$\text{Fat \%} = \frac{\text{Final weight of flask} - \text{Empty weight of flask}}{\text{Weight of sample}} \text{ X } 100$$

c. Determination of protein content of bitter gourd

Protein contents of bitter gourd determined by using Micro-Kjeldhal method. The protocol is described by AOAC (1990) [1].

Process of digestion

Defatted and moisture free Powderd sample was weighed around 200 mg which was added with a pinch of catalyst

mixture made up of potassium sulphate, copper sulphate and mercuric oxide in the ration of K_2So_4:$CuSo_4$:HgO red (91:8.2:0.8g), which is then feed in the digestion flask. The process of digestion was carried out with addition of 5 ml concentrated sulphuric acid (H_2SO_4) for 2 to 3hr at 45 ^oC until the mixture become colorless.

Neutralization and distillation process

The digested colorless sample diluted to the 50 ml by distilled water in volumetric flask and made final quantity made to 50 ml. Then the 5 ml of digested and diluted aliquot was neutralized with 40 percent sodium hydroxide containing 5g of sodium Thi-osulphtate solution. The process of distillation was carried out and then liberated ammonia was trapped in 2 percent solution of boric acid which contains methyl red indicator.

Titration

The trapped ammonia was titrated against 0.01N H_2SO_4 Solution. The titre value was measured and percent nitrogen was calculated by using following formula and then percent protein was calculated by multiplying with nitrogen factor 6.25. Carry out the same procedure for blank sample.

$$\% N = \frac{\text{CBR X Normality of } H_2SO_4 \text{ X Moles of Nitrogen X D.F}}{\text{Wt. of sample (g)}} \text{ X } 100$$

Where

CBR=Sample burette reading (SBR) - Blank burette reading (BBR)

Normality of acid (H_2SO_4) = 0.01N

Moles of Nitrogen =14/1000

% Protein = % Nitrogen X 6.25

d. Determination of carbohydrate of bitter gourd

The carbohydrate content of bitter gourd was determined by using the phenol sulphuric acid method**.** Accurately weigh 200 mg of dried and defatted bitter gourd sample in test tube and kept in refrigerated condition, add 2 ml of 70 percent hydrochloric acid and prepare its paste with glass rod in cold condition. Slowly transfer the same in 500 ml conical flask by using 23 ml of distilled water and reflux in to boiling water bath for 3 hours to ease in hydrolysis. Cool the resultant hydrolysate and then centrifuge or filter through Whatman No. 42 filter paper and by adding distilled water make final volume of 100 ml. Take a 0.2 ml of volume of aliquot for determination. Add 0.2 ml of 80 percent phenol in test tube followed by adding 5 ml of 96 percent concentrated H_2So_4. Vigorously shake the content of test tube on vertex mix or by manually after 10 min. Then read the optical density at 480 nm on a spectrophotometer.

- **Standard curve prepartion**

D-glucose (100 mg) used in 100 ml volumetric flask. Volume was made to 100 ml by distilled water. One ml from stock solution contained 1000 mg glucose. A standard calibration curve was made by using D-glucose as a standard sugar. Prepare a standard curve by taking 0,0.2,0.4,0.6,0.8 and 1.0 ml of standard glucose in the series of test tube with respect to 0,20,40,60,80 and 100 microgram respectively. Make up the volume of every test tube with distill water. Add 0.2 ml of 80 percent phenol in every test tube followed by 5 ml of 96 percent concentrated H_2So_4. Vigorously shake the content of test tube on vertex mix at last of 10 min record the optical density at 480 nm on a spectrophotometer and then prepare standard graph. Calculate the percentage of carbohydrate in the sample using the standard graph.

$$\text{Total carbohydrate (\%)} = \frac{\text{Sugar value from graph (mg) x total vol. of extract (ml)}}{\text{Aliquot sample used (0.2) x weight of sample}} \text{X } 100$$

e. Total ash content of bitter gourd

Weigh the 5 g bitter gourd into silica crucible, which was heated at low flame till all the material was completely burned and charred (smokeless) and cooled. The Procedure was preceded by keeping the crucible in muffle furnace for about 4 hr at 550 ^0C. The sample was cooled in desiccators and weighted after cooling. Repeat the process until two repeated weights were same. The percent ash was calculated by calculating the difference between the initial and final weight (AOAC, 2005) [2].

$$\text{Ash (\%)} = \frac{\text{Weight before heating – Weight after heating}}{\text{Weight of sample}} \text{ x } 100$$

f. Determination of fiber contents of bitter gourd (*Momordica charantia)*

About 2g of the bitter gourd sample were weighed into a 600 ml long beaker. 200ml of hot 1.25 percent H_2SO4 was added. Beaker was then kept on digestion apparatus with preheated plates, boiled, refluxed for 30 min and then filtered through Whiteman filter paper by gravity. The beaker was washed with distilled water. The residual part was washed on the paper with distilled water until the filtrate was become neutral. The residual contents were then transferred from the filter paper to the beaker which contains 200 ml of hot 1.25% sodium hydroxide solution. The chemically treated sample was then filter through filter paper. The paper with residue was placed into a crucible, which was then dried at 100 ^0C overnight, cooled in a dessicator and weight was recorded (weight A).The samples were placed in furnace at 600 ^0C for 6 hrs, which was then cooled in a dessicator and again take the weight (weight B). The loss in weight during burning represents the weight of crude fiber (AOAC, 2005) [2].

$$\% \text{ Fibre} = \frac{\text{(Weight A) – (weight B)}}{\text{Sample weight 1}} \text{ x } 100$$

2.3 Determination of minerals

Analysis of minerals was performed to estimate the macro and micro-elements available in bitter gourd and prepared value added food products.

2.3.1 Preparation of mineral solution

In a boiling water bath, the ash obtained by the above procedure was moisture with glass distilled water (0.5-1 ml), and concentrated hydrochloric acid was added and evaporated to dryness. Again 5 ml of concentrated hydrochloric acid was applied to dryness and evaporated as before. Finally 4 ml of distilled water and 5 ml of hydrochloric acid were added. This solution was heated over a boiling bath of water and filtered into the 100 ml volumetric flask using which man filter paper No.4. After the volume was cooled and made to 100 ml using distilled water and the correct aliquot was used for calcium and iron estimation.

a. Procedure for determination of calcium

25 ml of mineral solution was diluted to 150 ml with distilled water and then ammonia solution was neutralized using methyl red as an indicator before the pink color shifts to yellow. The solution was then heated and added with 10 ml of 6 percent ammonium oxalate.

This mixture was boiled for a sometime, and then combined with concentrated glacial acetic acid (99.9 percent) until the change of color was clearly pink. The mixture was held aside in a warm place (overnight), and the supernatant was measured with a drop of ammonium oxalate when precipitate settled to ensure precipitation was completed. The testing content was filtered through filter paper, and washed with distilled water. The precipitate was transferred to a beaker by making a hole in the filter paper center and twice rinsed by 5 ml of 2N H_2SO_4 solution. Then solution was heated to 70 ^{0}C and titrated against 0.01N potassium per magnet (KMNO4), and blank sample was also run simultaneously.

1ml of 0.01N $KMNO_4$ = 0.2004 mg of calcium

b. Procedure for determination of phosphorus

The contents of phosphorus were calculated using the colorimetric test. In this order 1 ml of hydroquinone and 1 ml of sodium carbonate solutions were applied to an aliquot (0.1 ml) of the ammonium molybdate mineral solution. The amount was then made with distilled water up to 15 ml, and the solution was thoroughly mixed. After 30 min the optical density (OD) of this solution was calculated in a photoelectric colorimeter, using a red filter (660 nm) against a blank reagent (Made in the same way as the test except that the test solution was omitted). After following the same procedure as mentioned above, the phosphorus content of the sample was read from a standard curve prepared with standard phosphate solution (range 0.01-0.1 mg of phosphorus).

c. Procedure for determination of magnesium

Colorimeteric method was employed for determinations of magnesium content of bitter gourd. Take 10 ml of ginger ash solution into a 15 ml graduated centrifuge tube. Add 1 drop of indicator (Methyl red). Neutralize the bitter gourd ash solution with NH_4OH and ammonium oxalate and finally make the solution of 13 ml volume. Mix well and kept aside for overnight.

Centrifuge the mixture for 10 min. and then remove the precipitate obtained. Measure 1 ml of the collected supernatant liquid into centrifuge tube of capacity 15 ml. Add 3 ml of distilled water, ammonium phosphate (1 ml) and NH_4OH (2 ml). Mix and allow to stand stagnant for overnight. Centrifuge for 7 min, and remove the obtained supernatant liquid, mix with 5 ml diluted NH_4OH, again centrifuge for 7 minutes and remove supernatant. Remove the water of precipitate by keeping the tube to container of hot water. Add 1 ml of diluted hydrochloric acid and 5 ml of distilled water to dissolve the precipitate. Add molybdic acid solution (1 ml), hydroquinone solution (0.5 ml) and sodium sulphite solution (0.5 ml). Then mix and allow stand aside for 30 min. Transfer the colorimeter tube containing solution and read the absorbance in a colorimeter using filter. Calibrate the instrument scale to zero reading.

d. Procedure for determination of iron and zinc

Iron and zinc content of bitter gourd was determined by using atomic absorption spectroscopy method by AOAC (1990) [1].

2.4 Color characteristics of dried bitter gourd

Color characteristics of dried bitter gourd was determined by using Hunter lab colorimeter (Model No. ColorFlex EZ) from the Department of Horticulture, College of Agricultural, VNMKV, Parbhani. Hunter lab colorimeter measured the color value in terms of the value L* for (0=black, 100=white), a* for (+value=red, -value=green) and b* (+value=yellow, -value=blue) with a white tile for instrument calibration (Rajiv *et al.* 2015) [18].

2.5 Estimation of total chlorophyll and carotene contents of bitter gourd

1 g of dried bitter gourd was weighed and was ground in pestle-mortar with 5 ml distilled water to a paste. The contents were transferred to a centrifuge tube and the total volume was made up to 10 ml with distilled water. 0.5 ml from the tube was transferred to a tube containing 4.5 ml of 80% acetone. The contents were centrifuged at 4000 rpm for 15 min. The absorbance of the supernatant was measured at the following wavelengths 645 and 663 nm (Garg *et al*., 2012) [7]. The optical density was measured and the chlorophyll contents in the original bitter gourd extract was estimated using the formula given by Talreja, (2011) [24],

Total chlorophyll (mg/ml) = 20.20 A_{645} + 08.02 A_{663}
Chlorophyll 'a' (mg/ml) = 12.70 A_{663} – 02.69 A_{645}
Chlorophyll 'b' (mg/ml) = 22.90 A_{645} – 04.68 A_{663}

These can be converted to chlorophyll content in mg/g dry weight as follows:

$$\text{Chlorophyll 'a' (mg/g)} = \frac{12.3 \times \text{O.D. at 663 nm} - 0.86 \times \text{O.D. at 645 nm} \times V}{a \times 1000 \times W}$$

$$\text{Chlorophyll 'b' (mg/g)} = \frac{19.3 \times \text{O.D. at 645 nm} - 3.6 \times \text{O.D. at 663 nm} \times V}{a \times 1000 \times W}$$

Total Chlorophyll (mg/g) = a + b

Here, O.D. = Optical Density
V = Final volume of chlorophyll extract in 80% acetone
W = Dry weight of plant material
a = the length of light path in the cell (usually 1 cm)

$$\text{Total carotene (mg/g)} = \frac{1000 \times A_{470} - 1.63 \text{ chlorophyll a} \times 104.96 \text{ chlorophyll b}}{221}$$

3. Results and Discussion

3.1 Chemical composition of dried bitter gourd

The chemical composition of dried bitter gourd was analyzed by standard protocols. The effects of different drying techniques on average proximate composition of dried bitter gourd are presented in table 1.

Table 1: Effects of drying on percent chemical composition of dried bitter gourd (Percent)

Drying method	Moisture	Fat	Protein	Carbohydrate	Fiber	Ash
Sun drying	11.63	5.29	22.81	41.81	12.02	6.44
Cabinet drying	10.93	5.38	23.04	42.18	11.97	6.50
SE±	0.195	0.023	0.061	0.107	0.014	0.017
CD at 5%	0.616	0.076	0.186	0.358	0.044	0.058

*Each value is average of three determinations

The data presented in table 1 showed the effects of drying on chemical composition of dried bitter gourd. Drying of bitter guard resulted in removal of moisture contents to a larger extent which thereby increases the shelf life of the bitter gourd. It was observed that moisture contents of dried bitter gourd processed by sun drying was 11.63 percent whereas moisture contents of dried bitter gourd processed by cabinet drying was 10.93 percent.

Fat is one of the most important quality parameter which imparts nutritional quality of the food products. The drying of bitter gourd resulted in increasing the fat contents of the bitter gourd. The highest value for fat contents was observed in dried bitter gourd dried by cabinet drying i.e. 5.38 percent whereas fat contents of the dried bitter gourd dried by sun drying was 5.29 percent.

The highest percentage of protein was observed in dried bitter gourd dried by cabinet drying i.e. 23.04 percent whereas the protein contents of dried bitter gourd dried by sun drying was 22.81 percent. The changes in protein content of bitter gourd could be due to heating effect during drying conditions which result in losing of hydrophobic forces leading to a partial distribution of the all structures of protein. (Ihekoronye and Ngoddy, 1985) [10].

The fiber content in dried bitter gourd was increased as compared to fresh bitter gourd. The fiber contents of the dried bitter gourd processed by sun drying and cabinet drying were 12.02 and 11.97 percent respectively. The carbohydrate content in dried bitter gourd was increased as compared to fresh bitter gourd. The highest percentage of carbohydrate was observed with the bitter gourd processed by cabinet drying i.e. 42.18 percent whereas sun dried bitter gourd had 41.81 percent carbohydrate.

Ash is the inorganic residue remaining after the completer removal of water and other organic components from ginger by heating. The ash content is nothing but amount of mineral present in a food product. Minerals are more heat resistant and can sustain up to 600 ^{0}C and they have a low volatility as compare to other organic components. The increase in contents of ash might be due to removal of water which tends to increase the concentration of nutrients (Morris *et al*., 2004). The ash contents of dried bitter gourd processed by sun drying and cabinet drying were 6.44 and 6.50 percent respectively. The bitter gourd processed by cabinet drying was observed significantly superior over sun drying with respect to fat, protein, Fiber and ash contents.

Similar results were observed by Bakare *et al*. (2010) [5]. Satwase *et al*. (2013) [21] studied that the nutritional components like protein, carbohydrate, fat, fibre and ash content of drumstick leaves get increased when it was dried by different modes of drying like sun, shade, cabinet and oven drying.

3.2 Mineral composition of dried bitter gourd

Mineral content of dried bitter gourd is extremely important in justifying its food value. The results pertaining to minerals content of dried bitter gourd are presented in Table 2.

Table 2: Effects of drying on mineral composition of dried bitter gourd (mg/100g)

Drying method	Calcium	Phosphorous	Magnesium	Iron	Zinc
Sun drying	52.80	98.63	48.58	3.13	0.86
Cabinet drying	53.03	98.77	48.70	3.25	0.83
SE±	0.064	0.042	0.034	0.036	0.008
CD at 5%	0.217	0.133	0.111	0.117	0.027

*Each value is average of three determinations

The data presented in table 2 revealed the effects of different drying methods on mineral composition of dried bitter gourd. The dried bitter gourd processed by cabinet drying was found significantly superior over dried bitter gourd processed by sun drying with respect to calcium content. The calcium content of sample dried by cabinet drying was more as compare to sun drying i.e. 53.03 mg/100g. The calcium content of dried bitter gourd sample dried by sun drying was 52.80 mg/100g. According to Perez-Lopez *et al*. (2002) [17], the calcium content of food products was affected by change in temperature, treatment with calcium chloride and its concentration and treatment time.

The phosphorus helps in bone development, regulation of energy and nucleic acid metabolism. The sample dried by cabinet drying got highest value for phosphorus i.e. 98.77 mg/100g. The bitter gourd dried by sun drying had phosphorus content 98.63 mg/100g respectively. The magnesium contents of dried bitter gourd processed by sun drying and cabinet drying methods were 48.58 and 48.70 mg/100g respectively. The increase in magnesium content of food products is might be due to the heating of food during drying, minerals which do not loss and higher values in magnesium content were seen (Liman *et al*., 2014) [11]. The drying of the bitter gourd resulted in increase the mineral contents of the dried bitter gourd might be due to loss of water during drying process.

The iron contents of the dried bitter gourd processed by sun drying and cabinet drying were 3.18 and 3.25 mg/100g respectively. The zinc contents of the dried bitter gourd processed by sun drying and cabinet drying were 0.86 and 0.83 mg/100g respectively. The similar results were reported by Mahwish *et al*. (2018) [13]. Hassan *et al*. (2007) [9] studied the impact of drying on chemical composition *Gynandropsis gynandra* (*Capparaceae*) leaves and found that the mineral contents of leaves were significantly increased on dying except from sodium contents of leaves.

3.3 Color composition of dried bitter gourd

The visual assessment of bitter gourd powder by using colorimeter given the results which are presented in Table 3.

Table 3: Effect of drying on color characteristics of dried bitter gourd

Drying method	L*	a*	b*	Hue	Chroma
Fresh	37.25	-6.86	13.62	88.32	14.39
Sun	61.30	-2.33	23.11	79.51	23.68
Cabinet	59.21	-2.38	24.64	80.25	25.03
SE±	0.600	0.015	0.497	0.224	0.380
CD at 5%	2.065	0.049	1.528	0.728	1.339

Table 3 shows that, initial color characteristics of fresh bitter gourd were for *L**, *a** and *b** were 37.25, -.6.86 and 13.62 respectively. The color brightness were higher for sun dried bitter gourd (61.30) than cabinet dried biter gourd (59.21). It indicates that the dried bitter gourd powders become darken when the time exposure for drying increases and some uncontrolled parameters of drying process. This might be due to the browning reactions which hasten by temperature of drying and exposed time.

For *a** value (Greenness) value shows a negative direction. It indicated the greenness of dried bitter gourd powder. Highest greenness was observed for cabinet dried bitter gourd (-2.38) followed by sun dried bitter gourd (-2.33). The *b** value indicates the yellow to blue Color. The presented results indicate that cabinet drying of bitter gourd was significantly

superior over sun drying. The highest *b** value was obtained for cabinet (24.64) as compared to sun (23.11) dried bitter gourd powder. The results are in aligning with the findings of Sanmeena *et al*. (2012) [20] who studied the change in color values by varying drying temperature and medium.

The hue values for fresh bitter gourd, sun and cabinet dried bitter gourd powder were 88.32, 79.51 and 80.25 respectively. The chroma value was slight higher in cabinet dried bitter gourd (25.03) followed by sun dried bitter gourd (23.68) and fresh bitter gourd (14.39). Rudra *et al*. (2008) [19] reported that high temperature could resulted in replacement of magnesium in the chlorophyll by hydrogen, thereby converting chlorophylls to pheophytins. Color changes could be because of chlorophyll were reduced as a result of oxidative reaction in the cells. In addition, there is competition between chlorophylase enzyme and peroxidase enzyme. However, the rate of change varied with the temperature. The discoloration of dried bitter gourd powder was more affected by time, temperature and different drying method. This might be due to degradation of pigment of bitter gourd powder during drying process and browning reaction occurring resulting in the color changes (Asekun *et al*., 2007) [4].

3.4 Chlorophyll and carotene content of dried bitter gourd

Chlorophyll is a naturally present pigment in near about all the plants contributing green color to leaves and which helps plants to obtain energy from light. The chlorophyll contents were helps to give green color to finished food products and also acts as a nutraceutical agent to treat cardiovascular disease, cancer, skin disease and improves liver detoxification. The results obtained are presented in Table 4.

Table 4: Effect of drying on chlorophyll and carotene content of bitter gourd

Drying Method	Total Chlorophyll (mg/g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Total Carotene (mg/g)
Fresh	1.700	0.630	0.070	0.690
Sun	0.113	0.085	0.028	1.053
Cabinet	0.139	0.103	0.036	1.108
SE±	0.016	0.006	0.128	0.077
CD at 5%	0.047	0.015	0.384	0.236

Table 4 shows the total chlorophyll content of fresh bitter gourd fruit was higher than that of dried bitter gourd powder. However, less differences were seen between all the treatments. It was observed that there was decrease in total chlorophyll content with increase in drying temperature. Chlorophyll contain of fresh bitter gourd was found to be 1.708 mg/g, while sun and cabinet dried bitter gourd powder it was 0.113 and 0.139 mg/g, respectively. The result shows that drying has a significant impact on chlorophyll degradation; however, the level of chlorophyll losses is different for each herb species (Śledź and Witrowa-Rajchert, 2012) [23].

Chlorophyll ‘a’ is bluish-green while chlorophyll ‘b’ is yellow-green color pigment. The chlorophyll ‘a’ and ‘b’ were also decreased with drying in case of dried bitter gourd. The chlorophyll ‘a’ contents of fresh bitter gourd was 0.630 mg/g. The drying of bitter gourd resulted in decreasing the contents of chlorophyll ‘a’. The highest value for chlorophyll was observed in cabinet dried bitter gourd i.e. 0.103 mg/g whereas sun dried bitter gourd contain chlorophyll 0.085 mg/g. The drying of bitter gourd also resulted in decreasing the contents of chlorophyll ‘b’. The chlorophyll ‘b’ contents of fresh, sun dried and cabinet dried bitter gourd were 1.070, 0.028 and 0.036 mg/g respectively. These variations might be due to the stability of chlorophyll at varying drying conditions. The differences could be due to the stage of maturity of the leaves, fruits which were harvested for analysis as well as to varietal differences. Oladele and Aborisade (2009) [16] reported that chlorophyll content was highest in fresh leaves and decreased with drying in Indian spinach.

The total carotene contents of fresh bitter gourd was 0.690 mg/g. The carotene contents of bitter gourd were increased during drying. The highest value for carotene was observed in dried bitter gourd dried by cabinet drying i.e. 1.108 mg/g whereas sun dried bitter gourd contain 1.053 mg/g of total carotene. The similar results were obtained by Singh and Sagar (2013) [22].

4. Conclusion

From the present investigation it was concluded that drying of bitter gourd resulted in increasing and concentrating the nutrients present in bitter gourd. The cabinet drying method was found significantly superior over sun drying method with respect to protein, fat, fiber, ash, calcium, magnesium, Phosphous, iron, total chlorophyll and total carotene contents.

5. References

1. AOAC. Official methods of analysis. Association of Official Analytical Chemists. 15th Edition, Washington D. C 1990.
2. AOAC. Official Methods of Analysis of the AOAC International. 8thed. Association of Official Analytical Chemists, Gaithersburg, MD 2005.
3. Agrawal M, Kamal R. *In vitro* clonal propation of *Momordica charantia* L. Indian Journal of Biotechnology 2004;1(3):426-430.
4. Asekun OT, Grierson DS, Afolayan AJ. Effects of drying methods on the quality and quantity of the essential oil of *Mentha longifolia* L. subsp *Capensis*. Food Chemistry 2007;101(3):995-998.
5. Bakare RI, Magbagbeola OA, Akinwande AI, Okunowo OW. Nutritional and chemical evaluation of *Momordica charantia*. Journal of Medicinal Plants Research 2010;4(21):2189-2193.
6. Duke JA. Handbook of medicinal herbs. CRC Press, Boca Raton FL 1985, 315-316.
7. Garg D, Muley A, Khare N, Marar T. Comparative analysis of phytochemical profile and antioxidant activity of some Indian culinary herbs. Research Journal of Pharmaceutical, Biological and Chemical Sciences 2012;3(3):845-854.
8. Grover JK, Yadav SP. Pharmacological actions and potential uses of *Momordica charantia*. A Review Journal of Ethnopharmacology 2004;93(1):123-132.
9. Hassan SW, Umar RA, Maishanu HM, Matazu JK, Faruk UZ, Sami AA. The effects of drying method on the nutrients and non-nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*). Asian Journal of Biochemistry 2007;2(5):349-353.
10. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. London, Macmillan Publisher 1985, 293-307.
11. Liman MH, Abdullahi AS, Maigoro AL, Kabiru JU. Effects of three drying techniques on mineral composition of some leafy garden vegetables. IOSR Journal of Applied Chemistry 2014;7(1):38-42.

12. Lonkar PB, Chavan UD, Pawar VD, Bansode VV, Amarowicz R. Studies on preparation and preservation of lemongrass (*Cymbopogon flexuosus* (Steud) Wats) powder for tea. Emirates Journal of Food and Agriclture 2013;25(8):585-592.
13. Mahwish Farhan S, Mahr N, Muhammad T, Nadeem. Minerals and phytochemical analysis of bitter melon fruits and its components in some indigenous and exotic cultivars. Bioscience Journal 2018;34(6):1622-1631.
14. Morris A, Barnett A, Burrows O. Effects of processing on nutrient content of foods. Cajarticles 2004;37:160-164.
15. Nazimuddin S, Naqvi SS. Flora of pakistan No 154, cucurbitaceae. Dept. Botany University Karachi 1984, 56.
16. Oladele OO, Aborisade AT. Influence of different drying methods and storage on the quality of Indian spinach (*Basella rubra* L.). American Journal of Food Technology 2009;4(2):66-70.
17. Perez-Lopez I, Welti-Chanes J, Lopez-Malo A, Palou E, Ibarz A. Calcium incorporation in papaya by low temperature blanching in Proceedings of the IFT Annual Meeting Book of Abstracts, Anaheim, California, USA 2002.
18. Rajiv J, Milind Aashitosh A, Imnamdar Sakhare S, Rao GV. Roller milled black gram (*Phaseolus mungo*) semolina and its influence on the quality characteristics of high protein pasta. Journal of Food Science and Technology 2015;52(4):2464-2468.
19. Rudra SG, Singh H, Bsau S, Shivhare US. Enthalpy, entropy compensation during thermal degradation of chlorophyll in mint and coriander puree. Journal of Food Engineering 2008;86:379-387.
20. Sanmeema N, Poomsaad N, Wiset L. Lemongrass drying under hot air and nitrogen as drying medium at different drying temperatures. Journal of Science and Technology 2012;31(5):650-654.
21. Satwase AN, Pandhre GR, Sirsat PG, Wade YR. Studies on drying characteristic and nutritional composition of drumstick leaves by using sun, shadow, cabinet and oven drying methods. Open Access Scientific Reports 2013;2(1):584-587.
22. Singh U, Sagar VR. Effect of drying methods on nutritional composition of dehydrated bitter gourd (*momordica charantia* l.) rings. Agriculture for Sustainable Development 2013;1(1):124-142.
23. Śledź M, Witrowa-Rajchert D. Influence of microwave convective drying on chlorophyll content and colour of herbs. *Acta Agrophysica* 2012;19(4):865-876.
24. Talreja T. Biochemical estimation of three primary metabolites from medicinally important plant *Moringa oleifera*. International Journal of Pharmaceutical Sciences Review and Research 2011;7(2):186-188.
25. Taylor L. Technical data report for bitter melon (*Momordica charantia*) herbal secrets of the rainforest. 2nd edition. Sage Press, Austin 2002.