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Studies on effects of different processing methods on morphological and nutritional quality attributes of dried ginger (*Zingiber officinale* L.) rhizome

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Abstract
Present work have been undertaken to study the impact of different processing methods on physical quality characteristics, chemical composition and mineral composition of dried ginger rhizome. Ginger is cultivated in countries like India, China, Nigeria, Indonesia, Bangladesh, Thailand, Philippines, Jamaica etc. Ginger rhizomes are rich source of carbohydrates, vitamins, minerals and iron. Ginger known for its Analgesic, Antibacterial, Antidiabetic, Antiemetic, Antifungal, Anthelmintic, Anti-inflammatory, Antithrombic, Antitumor, Antitussive, Antiulcer, Antiviral properties. The ginger dried by different methods like surat method, mulbar method and MPKV rahuri method. From the research it was observed that ginger processed by mulbar method obtained higher value for length, width and geormetric mean diameter where as ginger processed by MPKV method obtained higher value for thickness and bulk density. The chemical composition of processed ginger revealed that ginger processed by surat method got higher value for carbohydrate and mulbar method obtained higher value for moisture content and ash content where as MPLV method obtained higher value for fat, protein and fiber content. The mineral composition of processed ginger showed that ginger sample processed by mulbar method obtained higher reading for calcium, copper and manganese where as MPKV method obtained higher reading for phosphorus, magnesium, iron and zinc. From the research it was concluded that ginger sample processed by MPKV method is found superior than surat and mulbar method with respect to nutritional quality.

Keywords: Chemical composition, Ginger, Mineral composition, MPKV method, method, Surat method

Introduction
Ginger (*Zingiber officinale roscoe*) is sympodial branched and horizontal rhizome having size about 5 to 15 cm length, width about 3 to 6 cm and thickness about 0.5 to 1.5 cm. shape is laterally flattened on the upper side with short flattened oblique, obviate branches or fingers. Ginger originated from India from where it was introduced to Africa and Caribbean, however no definite information on the primary centre of domestication of ginger is available (Prabhakaran, 2013) [18].

The different varieties of ginger cultivated in the India some of them are Varada, Mahima, Rejhata, Suruchi, Suprabha, Himanchal, Maran, Nadia, Karakkal, Mananthody, Sabarimala, Ellakallan, Kakakkalan, Kozhikkalan, Pink ginger, Bhaise, Jolpaiguri. Cochin ginger and calicut ginger are the popular Indian ginger varieties in the world market.

Generally ginger contains carbohydrates 71.6 g, sugars 3.39 g, dietary fiber 14.1 g, fat 4.24 g, protein 8.98 g, thiamine (B1) 0.046 mg, riboflavin (B2) 0.17 mg, niacin (B3) 9.62 mg panthenic acid (B5) 0.477 mg vitamin (B6) 0.626 mg folate (B9) 13 µg vitamin C 0.7 mg, calcium 114 mg, iron 19.8 mg, magnesium 214 mg, manganese 33.3 mg, phosphorus 168 mg, potassium 1320 mg, sodium 27 mg and zinc 3.64 mg (Dhanik *et al*., 2017) [7]. Ginger is a complex substance consisting of more than 60 compounds (Srivastava *et al*, 2000) [24].

Ginger known for its medicinal value for mankind. It is also used as Antioxidant, Antitoxic, Eicosanoid balance, Enzyme activity, Probiotic support, Serotonergic, Systemic stimulant. Its demonstrated effects are Analgesic, Antibacterial, Antidiabetic, Antiemetic, Antifungal, Anthelmintic, Anti-inflammatory, Antithrombic, Antitumor, Antitussive, Antiulcer, Antiviral, Gas or flatulence, Headaches, Immune supportive, Migraine Headache, Morning sickness, Nausea, Sinus congestion, Thermoregulatory, etc. (Sharma, 2017) [22].

Fresh ginger are perishable in nature and are spoiled due to improper handling, growth of

spoilage microorganisms, susceptibility to rhizome rot, wilting and sprouting, action of naturally occurring enzyme, chemical reactions and structural changes during storage (Baranowski, 1985) [6]. Processing ginger into dried product is an important method of reducing perishability and also to increase storage stability (Pezzutti and Crapiste, 1997) [17]. Drying processes has been proved to be viable and appropriate. Drying is important because it increases the shelf life, reduces the weight, simplifies the transport, confirms the availability at any time, protects from enzymes and spoilage, reduces the cost of packaging, retains the flavor for long time, remove necessity of refrigeration.

There are different processing method which are used for preparation of ginger sunth, namely mulbar method, surat method and MPKV, Rahuri method. In mulbar method Rhizomes are soaked in 2% clear lime water $Ca(OH)_2$ for 6 hrs. They are then transferred to sulphuring chamber for12 hrs. The complete procedure is repeated 3 times to bleach the ginger and give it white color before drying.

In surat method green ginger is soaked in water to facilitate removal of skin. Skin is scrapped-off with pieces of sharpened bamboo or bits of sea shells or choir with great care and skill to avoid loss of essential oil. Scrapped produce is washed and dried in sun for 3-4 days and hand rubbed. It is again soaked in water for 2 hr, dried and then rubbed to remove all the remaining bits of skin. Sun drying also helps to bleach the produce. This type of curing is rather slow but preserves the flavor and hence is beneficial.

In MPKV, Rahuri method fully matured rhizomes are taken, washed and peeled. They are dipped in 20%, 25% and 50% caustic coda solution (Sodium hydroxide) for 5 minutes, 1 minute and ½minute respectively. They are then transferred to 4% citric acid solution for 2 hours. They are then thoroughly washed with water and dried in sun till moisture content is 15-20%. Finally they are polished and packed.

2. Material and methods

2.1 Procurement of ginger (*Gingiber Officinale*)

The prominent variety of *Gingiber Officinale* (Ginger) "Kochin" was selected with concern of horticulturist. The good quality raw material (Ginger) required for present investigation procured from aurangabad.

2.2 Chemicals and Glassware

Chemicals of analytical grade and sufficient glassware required will be available in the laboratory, Department of Food Engineering, College of Food Technology. V.N.M.K.V. Parbhani.

2.3 Methods

2.3.1 Physical properties of ginger

The physical properties of ginger such as length, width, thickness, geometric mean diagram, bulk volume and bulk density was determined.

a) Determination of length, width and thickness of ginger

Determination of Axial Dimensions Alphabets x, y, z are used to represent length, width and thickness respectively. Vernier calliper (0.001 mm accuracy) was used in taking the measurement of length, width and thickness.

b) Determination of geometric mean diameter

The geometric mean was calculated using Equation described by Mohsenin (1986) [13].

$$Gm = (XYZ)^{1/3}$$

Where:
Gm is the Geometric Mean,
x is the length of the rhizome,
y is the width of the rhizomes,
z is the thickness of the rhizomes

c) Determination of Bulk Density

The bulk density of the ginger rhizomes was determined as the ratio of bulk weight of ginger to the bulk volume.
Bulk density = Weight of ginger/ Bulk volume

2.3.2 Proximate composition of ginger

Ginger analyzed for proximate composition including moisture, fat, protein, total carbohydrate, crude fiber, ash and mineral content will be determined.

a) Determination of moisture

Moisture will be estimated by accurately weighing the 5 g sample, it was ground and subjected to oven drying at 105 ^{0}C for 4 hr. It was again weighed after cooling in desiccators until constant weight. The resultant loss in weight was calculated as moisture content (AOAC, 1990).

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

b) Determination of fat

5g ground demoisturised sample weighed accurately in thimble and defatted with petroleum ether in Soxhlet apparatus for 6-8 hrs at 60 ^{0}C. The resultant ether extract was evaporated and lipid content was calculated (AOAC, 1990).

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

c) Determination of protein

Protein content will be determined by Micro-Kjeldhal method as per the method given by AOAC (1990).

- **Digestion**

Accurately weighed 200 mg of defatted ground sample and add a pinch of catalyst mixture K_2So_4:$CuSo_4$:HgO red (91:8.2:0.8g) then transferred into the digestion flask, digestion was carried out with 5 ml concentrated H_2SO_4 for 2-3hr at 45ºC till the content becomes colourless.

- **Neutralization and distillation**

Digested sample will be diluted to the 50 ml in volumetric flask and made final volume to 50ml with double glassed distilled water. Then the 5ml of aliquot was neutralized with 40% NaOH containing 5g of sodium thiosulphtate. Distillation was carried and liberated ammonia was absorbed in 2% boric acid solution containing methyl red as indicator.

- **Titration**

The collected ammonia was titrated against 0.01N H_2SO_4. Titre reading was noted, % Nitrogen was calculated by using following formula and % protein was calculated by multiplying 6.25. Simultaneously a blank sample was also run.

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

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

Determination of total carbohydrate
The total carbohydrate content will be determined by using the phenol sulphuric acid method**.** Weigh accurately 200 mg of dried defatted sample in test tube kept in ice chilled condition, add 2 ml of 70% HCL and make its paste with glass rod in chilled condition. Transfer slowly the same in 500 ml conical flask by using 23 ml distilled water and reflux in to boiling water bath for 3 hr to facilitate hydrolysis. Cool the hydrolysate and centrifuge or filter through Whatman No. 42 filter paper and make final volume 100 ml with distilled water. Take a known volume of aliquot 0.2 ml for analysis. Add 0.2 ml of phenol 80% in test tube followed by 5 ml of conc H_2So_4 (96%). Shake the content of test tube vigorously on vertex mix or manually After 10 min read the OD at 480 nm on a spectrophotometer. \

Preparation of standard curve
D-glucose (100 mg) will taken in 100 ml volumetric flask. Volume was made to the mark with distilled water. One ml of stock solution contained 1000 mg glucose. A standard calibration curve was prepared using D-glucose as a standard sugar. Prepare a calibration curve (standard curve) by taking 0,0.2,0.4,0.6,0.8 and 1.0 ml of std glucose (working solution) in series of test tube correspond to 0,20,40,60,80 and 100 microgram resp. Make up the volume of each test tube with distill water. Add 0.2 ml of phenol 80% in each test tube followed by 5 ml of conc. H_2So_4 (96%). Shake the content of test tube vigorously on vertex mix or manually After 10 min read the OD at 480 nm on a spectrophotometer and prepare standard graph.
Calculate the amount of total carbohydrate in the sample using the standard graph.
Total carbohydrate in sample (%) =

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

Total ash
Sample of 5 g was weighed into crucible, which was heated at low flame till all the material was completely charred (smokeless) and cooled. Then it was kept in muffle furnace for about 4 hr at 550^0C. It was again cooled in desiccators and weighed. Repeat until two consecutive weights were constant. The per cent ash was calculated by knowing the difference between the initial and final weight (AOAC, 2005).

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

Determination crude fiber
About 2g of the sample were weighed into a 600ml long beaker. 200ml of hot 1.25% H2SO4 was added. Beaker was placed on digestion apparatus with preheated plates, boiled, refluxed for 30mins and filtered through Whiteman GF/ A paper by gravity. The beaker was rinsed with distilled water. The residue was washed on the paper with distilled water until the filtrate was neutral. The residue was transferred from the paper back to the beaker containing 200 ml of hot1.25% NaOH. Steps 4 and 5 were repeated. The paper with residue was transferred into a crucible, dried at 100oCovernight, cooled in a dessicator and reweighed (weight A).The samples were put in furnace at 600oC for 6 h, cooled in a dessicator and reweighed (weight B). The loss in weight during incineration represents the weight of crude fibre (AOAC, 2005) [5].

$$\% \text{ crude fibre} = \frac{(\text{weight A}) - (\text{weight B}) \quad \text{x } 100}{\text{Sample weight 1}}$$

2.3.3. Determination of minerals
Minerals analysis was carried out to estimate the macro and micro elements present in ginger samples and prepared value added food products.

2.3.3.1 Mineral solution preparation
The ash obtained by above procedure was moisture with glass distilled water (0.5-1 ml) and concentrated HCl was added and evaporated to dryness on a boiling water bath. Again 5 ml concentrated HCl was added and evaporated to dryness as before. Lastly 4 ml of HCl and 5 ml of distilled water were added. This solution was warmed over a boiling water bath and filtered into the 100 ml of volumetric flask using what man No.4 filter paper. After cooling the volume was 32 made to 100 ml using distilled water and suitable aliquot was used for the estimation of calcium and iron.

Determination of calcium
25 ml mineral solution was diluted to 150 ml with distilled water and neutralized with ammonia solution using methyl red as indicator till pink color changes to yellow. Further the solution was boiled and 10 ml of 6 percent ammonia oxalate was added. This mixture was boiled for few minutes and added with concentrated glacial acetic acid (99.9 percent) till the color change was distinctly pink. The mixture was kept aside in warm place (overnight) and when precipitate settled down, the supernatant was tested with a drop of ammonium oxalate to ensure the completion of precipitation. The content were filtered through what man No.4 filter paper and given washings of warm distilled water. The precipitate was transferred to a beaker by making a hole in the centre of filter paper and by giving washings of H_2SO_4 (2N, 5 ml) twice. Then solution was heated to 70^0C and titrated against N/100 $KMNO_4$, simultaneously a blank was also run.
1ml of 0.01N $KMNO_4$ = 0.2004 mg calcium

Determination of phosphorus
Phosphorus contents were determined by the colorimetric method. To an aliquot (0.1 ml) of the mineral solution of ammonium molybdate, 1 ml of hydroquinone and 1 ml of sodium carbonate solutions were added in this order. The volume was then made to 15 ml with distilled water and the solution was mixed thoroughly. After 30 min the optical density of this solution was measured in a photoelectric colorimeter, against a reagent blank (prepared in the same way as the test except that the test solution was omitted) using a red filter (660 nm). The phosphorus content of the sample

was read from a standard curve prepared with standard phosphate solution (rang 0.01-0.1 mg P) following the same procedure as described above.

Estimation of magnesium

Magnesium was estimated by colorimeteric method. Measure 10 ml of ash solution into a 15 ml graduated centrifuge tube. Add 1 drop of methyl red indicator. Neutralise solution with NH_4OH and ammonium oxalate and make the solution to a volume of 13 ml. Mix and allow to stand overnight. Centrifuge for 10 min. and discard precipitate. Measure 1 ml of the supernatant liquid from above into a 15 ml centrifuge tube. Add 3 ml of water, 1 ml of ammonium phosphate and 2 ml of NH_4OH. Mix and allow standing overnight. Centrifuge for 7 min, discard the supernatant liquid, mix with 5 ml of dilute NH_4OH, centrifuge for 7 min and discard supernatant liquid. Dry the precipitate by placing the tube to container of hot water. Add 1 ml of dilute HCl and 5 ml of water to dissolve the precipitate. Add 1 ml of molybdic acid solution, 0.5 ml hydroquinone and 0.5 ml sodium sulphite solution. Mix and allow standing for 30 min. Transfer the solution to colorimeter tube and read the absorbance in a colorimeter using a No. 66 red filter. Set the instrument scale at zero with scale.

Determination of manganese

The manganese content was estimated according to the respective method as described in AOAC (2005) [5] using Atomic Absorption Spectrophotometer. 0.5 g sample was digested separately by using wet digestion method. The sample was first digested with 10 ml HNO_3 at a temperature of 60-70°C for 20 min and then digested with HCl at a temperature of 190°C till the solution become clear. The digested sample was transferred to 250 ml volumetric flask and volume was made with distilled water and then filtered. The solution was loaded into Atomic Absorption Spectrophotometer apparatus. The standard curve was prepared by running samples of known strength through atomic absorption spectrophotometer. The manganese contents of unknown samples were estimated by using the respective standard curve prepared for manganese.

Determination of iron

Iron content was determined by a-a, dipyridyl method described in AOAC (1990) exactly 10 ml of wet digested sample solution was pipetted into volumetric flask of 25 ml capacity in triplicates. 1 ml of hydroxylamine hydrochloride solution, 5 ml of acetate buffer solution and 2 ml of a-a, dipyridyl solution were added into each volumetric flask. The volume was made up to 25 ml with glass distilled water and the content was mixed. The intensity of the color developed was read in spetronic 20 at 510 nm. Iron content of the digested sample solution was read from the standard curve of known concentration of iron.

Preparation of standard curve

Pipette 0.0, 0.5, 1.0, 1.5, 2.0, 3.0 and 4.0 ml of Fe standard solution in to a series of 25 ml volumetric flasks and add to each of them exactly 0.2 ml of conc. HCl. Dilute each of them to exactly 10 ml with water, and then add reagents in the same way as for the sample, Plot the quantity of Fe (mg) against the absorbance.

$$\text{Iron content of sample (Mg Fe / 100 g sample)} = \frac{\text{Quantity of Fe in aliquot of Ash solution (from calibration curve)}}{\text{Aliquot of ash solution taken For determination}} \times \frac{\text{Total volume of ash solution}}{\text{Wt. of the sample taken for ashing}} \times 100$$

Determination of zinc

The minerals zinc was estimated according to the respective method as described in AOAC (2005) [5] using Atomic Absorption Spectrophotometer. 0.5g sample was digested separately by using wet digestion method. The sample was first digested with 10 ml HNO_3 at a temperature of 60-70°C for 20 min and then digested with HCl at a temperature of 190°C till the solution become clear. The digested sample was transferred to 250 ml volumetric flask and volume was made with distilled water and then filtered. The solution was loaded into Atomic Absorption Spectrophotometer apparatus. The standard curve was prepared by running samples of known strength through atomic absorption spectrophotometer. The mineral contents of unknown samples were estimated by using the respective standard curve prepared for each mineral.

g) Determination of copper

3.5.8.1. Preparation of copper standard calibration solutions

0.3927 g of CuSO4.5H2O was weighed and dissolved in 5ml of concentrated hydrochloric acid. It was diluted to 100 ml with distilled water in a volumetric flask. This was 1000 ppm copper solution. 10 ml of this solution was diluted to 100 ml with distilled water to get 1 ppm copper solution. Similarly 2ml, 3ml, 4ml and 5 ml of the 100 ppm solution was diluted to 100 ml in volumetric flasks to get 2 ppm, 3 ppm, 4 ppm and 5 ppm copper solutions. The Atomic absorption spectrophotometer was optimized with copper hollow cathode lamp and checked with 5 ppm copper solution to produce a minimum of 0.6 nm absorbance (Ramachandra *et al.*, 2012) [19].

$$\textbf{Cu \% = (ppm) x } \frac{100 \times 100 \times 100 \times 100 \times 100 \times 10\text{-}6}{10 \text{ —— } 10 \text{ —— } 10 \text{ —— } 1.0 \text{ ——}}$$

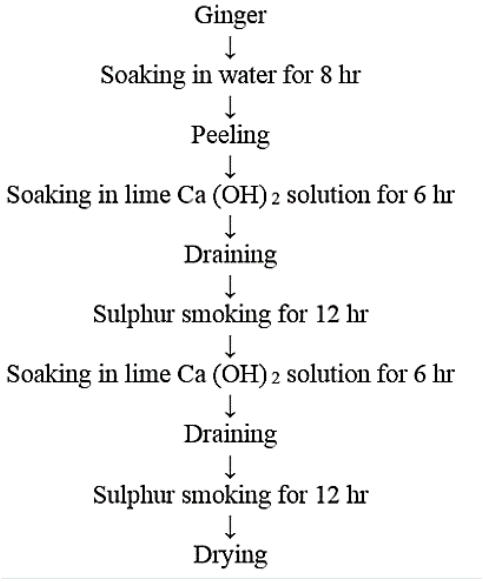
(1.0 is the weight of the sample in solution A)

2.3.4 Preparation of dried ginger (*Sunth*)

The ginger was cleaned to remove unwanted impurities and processed by mulbar method, surat method and MPKV, rahuri method, for preparation of ginger *sunth*.

3.3.4.1 Malbar method

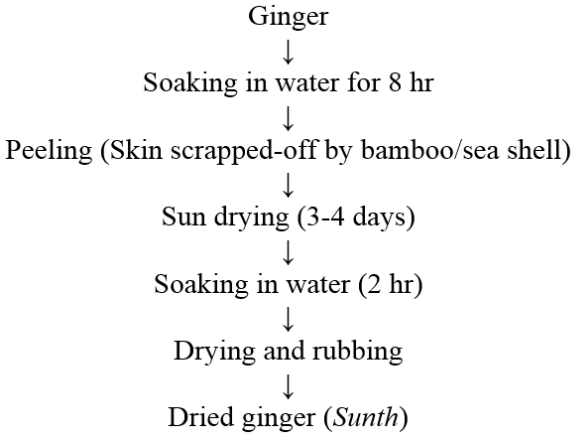
Rhizomes are soaked in 2% clear lime water $Ca(OH)_2$ for 6 hrs. They are then transferred to sulphuring chamber for12 hrs. The complete procedure is repeated 3 times to bleach the ginger and give it white color before drying.



Flow sheet 1: Preparation of dried ginger by malbar method

2.3.4.2 Surat method

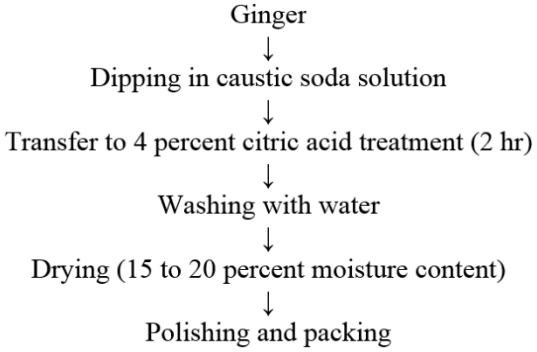
Green ginger is soaked in water to facilitate removal of skin. Skin is scrapped-off with pieces of sharpened bamboo or bits of sea shells or choir with great care and skill to avoid loss of essential oil. Scrapped produce is washed and dried in sun for 3-4 days and hand rubbed. It is again soaked in water for 2 hr., dried and then rubbed to remove all the remaining bits of skin. Sun drying also helps to bleach the produce. This type of curing is rather slow but preserves the flavor and hence is beneficial.



Flow sheet 2: Preparation of dried ginger by surat method

2.3.4.3 Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri method

Fully matured rhizomes are taken, washed and peeled. They are dipped in 20%, 25% and 50% caustic coda solution (Sodium hydroxide) for 5 minutes, 1 minute and ½minute respectively. They are then transferred to 4% citric acid solution for 2 hours. They are then thoroughly washed with water and dried in sun till moisture content is 15-20%. Finally they are polished and packed.



Flow sheet 3: Preparation of dried ginger by MPKV, rahuri method

3. Result and Discussion

3.1 Morphological characteristics of ginger rhizome

In order to characterize ginger rhizome, physical parameters *viz*. length, width, thickness, geometric mean diameter, bulk volume and bulk density was determined. The physical characteristics of ginger play a very important role in development of processing technology and on the quality of final products. The various physical properties of ginger rhizome is presented in table 1.

Table 1: Physical quality parameters of ginger (*zingiber officinale roscoe*)

S. No.	Physical parameter	Ginger rhizome
1	Length (cm)	10.85±1.67
2	Width (cm)	6.91±0.50
3	Thickness (cm)	3.52±0.21
4	Geometric mean diameter (cm)	6.41±0.53
6	Bulk density (kg/m^3)	486.62±3.51

*****Each value is average of three determinations

The data presented in table 1. revealed that size for fresh ginger rhizome for length (cm), width (cm) and thickness (cm) was 10.85±1.67 cm, 6.91±0.50 cm and 3.52±0.21 cm respectively. The geometric mean diameter (cm) observed for ginger rhizome was 6.41±0.53. The bulk density (g/cm^3) was 486.62±3.51 kg/m^3. Similar results were obtained by Akhtar *et al*. (2013) [3], Jayashree and Visvanathan (2011) [11] and Ajav and Ogunlade (2014) [2].

3.2 Proximate composition of ginger rhizome

Proximate composition generally represents the nutritional quality of product. It is necessary to determine the proximate composition of ginger rhizome so as to judge its impact on prepared value added food product after utilization as a novel ingredient. The proximate composition of ginger rhizome was determined and presented in Table 2.

Table 2: Average chemical composition of ginger rhizome

S. No.	Parameters	Ginger rhizome (%)
1	Moisture	87.65 ±1.20
2	Fat	1.95±0.45
3	Protein	4.48±0.32
4	Carbohydrate	11.15±0.66
5	Fiber	2.19±0.18
6	Ash	1.58±0.06

*Each value is average of three determinations

The data presented in Table 2. showed ginger rhizome contain 87.65±1.20 percent of moisture. This is expected since the sample has been subjected to drying to reduce the moisture content. Crude fat, crude protein, crude fiber and carbohydrate of ginger rhizome flour were observed 1.95±0.45 percent, 4.48±0.32 percent, 2.19±0.18 percent and 11.15±0.66 percent respectively. Ash content of ginger rhizome contained about 1.58±0.06 percent. Ash content is an indication of the level of minerals present in food material this suggests that ginger can help in boosting the mineral content of prepared value added food products. The obtained results for the proximate composition of ginger rhizome were found similar to that of results of Tanweer *et al*. (2014) []. EL-Ghorab *et al*. (2010) [8] investigate the chemical composition of ginger and observed that ginger contain 88.5±0.39% moisture tracked by 0.2±0.01% crude fat, 1.1±0.16% crude fiber, 1.5±0.07% ash, 1.2±0.17% protein and 7.6±0.67% nitrogen free extract.

3.3 Mineral composition of ginger rhizome

Mineral content of ginger rhizome is essential in justifying its food value. Calcium, iron, manganese, phosphorus, and zinc are the minerals of interest in current study. Minerals play a key role in various physiological functions of the body especially in the building and regulation processes. The data pertaining to mineral content is presented in Table 3.

Table 3: Average mineral composition of ginger rhizome

S. No.	Parameters	Ginger rhizome (mg/100g)
1	Calcium	14.17±0.32
2	Phosphorus	30.93±0.29
3	Magnesium	43.83±0.45
4	Iron	0.62±0.04
5	Manganese	0.65±0.02
6	Zinc	0.27±0.01
7	Copper	0.43±0.03

*Each value is average of three determinations

The data presented in table 3. showed the mineral composition of ginger rhizome. The macro minerals like calcium, phosphorus and magnesium were 14.17±0.32, 30.93±0.29 and 43.83±0.45 mg/100g respectively. Minerals especially calcium and phosphorus are required in human body in large amounts. Their deficiency results in arthritis, bone and tooth related disorders. The iron, manganese, zinc and copper was 0.62±0.04, 0.65±0.02, 0.27±0.01 and 0.43±0.03 mg/100g respectively. Iron is essential for blood formation owing to a major constituent of hemoglobin while zinc is required for fertility, insulin working as well as mental and body growth. The similar results were obtained by finding of Tanweer *et al*. (2014) [25].

3.4 Processing of ginger rhizome

3.4.1 Physical parameter of processed ginger rhizome

The ginger rhizome was processed by different processing methods for preparation of dried ginger rhizome (*Sunth*). The impact of processing on physical parameter of ginger rhizome is showed in table 4.

Table 4: Effects of processing on physical parameters of dried ginger rhizome

S. No.	Parameters	Surat method	Mulbar method	MPKV, method	SE±	CD at 5%
1	Length (cm)	7.58	7.86	7.62	0.215	0.757
2	Width (cm)	4.83	5.18	5.04	0.189	0.666
3	Thickness (cm)	2.16	2.25	2.31	0.069	0.242
4	GMD (cm)	4.29	4.50	4.45	0.142	0.499
5	Bulk density (kg/m^3)	473.35	477.81	480.21	2.651	9.342

*Each value is average of three determinations

The data presented in table 4. depict the impact of different processing methods on physical quality of dried ginger rhizome. The length (cm) for dried ginger rhizome processed by surat method, mulbar method and MPKV method was

7.58, 7.86 and 7.62 cm respectively. It was found that length of ginger rhizome processed by mulbar method was higher than MPKV method and surat method. the width of ginger rhizome processed by mulbar method (5.18 cm) is high than MPKV method (5.04 cm) and surat method (4.83 cm). Thickness (cm) value for ginger rhizome processed by surat, mulbar and MPKV method was 2.16, 2.25 and 2.31 cm respectively. The thickness for ginger processed by MPKV method was higher than other methods. The geometric mean diameter (cm) value for ginger rhizome processed by surat, mulbar and MPKV method is 4.29, 4.50 and 4.45 cm respectively. The bulk density (kg/m^3) value for ginger rhizome processed by surat, mulbar and MPKV method is 473.35, 477.81 and 480.21 kg/m^3 respectively. The similar results were obtained by research outcome of Onu and Okafor (2002) [15] and Jayashree and Visvanathan (2011) [11].

3.4.2 Chemical composition of processed ginger rhizome

The chemical composition of processed dried ginger was analyzed by standard technique. The moisture content of the dried samples was not significantly different and it was drastically reduced from 78.65% in fresh sample to 8.28% in dried samples, representing an index of good storage quality. The effects of different processing methods on chemical composition of dried ginger rhizome are presented in table 5.

Table 5: Effects of processing on chemical composition of dried ginger rhizome

S. No.	Chemical composition (%)	Surat method	Mulbar method	MPKV, method	SE±	CD at 5%
1	Moisture	8.28	9.04	8.47	0.265	0.960
2	Fat	2.60	3.99	4.25	0.133	0.481
3	Protein	8.63	8.70	10.57	0.469	1.699
4	Carbohydrate	71.67	68.65	68.08	1.082	3.921
5	Fiber	4.25	3.66	4.25	0.097	0.351
6	Ash	4.56	5.95	5.15	0.186	0.674

*Each value is average of three determinations

The data presented in table 5. showed that maximum percent of moisture was present in dried ginger sample which was dried by mulbar method i.e. 9.04 percent. The dried ginger rhizome processed by surat and MPKV method contained moisture content 8.28 and 8.47 percent respectively.

The fat content of dried ginger rhizome (*Sunth*) was increased after drying. The ginger processed by MPKV method retained the good percentage of fat content i.e. 4.25 per cent. The ginger processed by surat and mulbar method had fat content 2.60 percent and 3.99 percent. It shows that ginger sample dried by MPKV method was significant with surat and mulbar method. It represents a good index of storability as it reduces the susceptibility of the powder to lipid oxidation. the ginger sample dried by MPKV method founded the highest percentage of protein i.e. 10.57 percentage. The ginger sample dried by surat and mulbar method founded protein content 8.63 and 8.70 percent respectively. The change in protein content could be attributed to mild heating effect associated with all the drying conditions which could result in the unzipping of hydrophobic forces leading to a partial distribution of the primary, secondary, tertiary and quaternary structure of the protein molecule (Ihekoronye and Ngoddy, 1985) [10].

The fiber content in dried ginger was increased as compared to fresh ginger. The fiber content of dried samples was found in the range of 3.66 to 4.25 per cent. The ginger sample dried by surat method and MPKV method had good percentage of fiber i.e. 4.25 percent. The ginger sample processed by mulbar method had fiber content 3.66 percent. The carbohydrate content in dried ginger was increased as compared to fresh ginger. The carbohydrate content of dried samples was found in the range of 68.08 to 71.67 per cent. The ginger sample dried by surat method had highest percentage of carbohydrate i.e. 71.67 percent. The ginger sample processed by mulbar and MPKV method had carbohydrate content 68.65 and 68.08 percent respectively.

The ginger sample dried by mulbar method observed good percentage of ash content i.e. 5.95 percent than other samples. The ash contents of dried ginger rhizome processed by surat and MPKV method was 4.56 and 5.15 percent respectively. Ash is the inorganic residue remaining after the water and organic matter have been removed by heating a food.

The ash content is a measure of amount of mineral present within a food. Minerals are not destroyed by heating and they have a low volatility compared to other food components. The result showed that ginger processing by mulbar method was significant with ginger processed by surat and MPKV method with respect to moisture and ash content. The increase in ash content observed in this study could be due to the removal of moisture which tends to increase the concentration of nutrients (Morris *et al*., 2004) [14].

Similar results were by research outcome of Shirin and Jamuna (2010) [23]. Agu *et al*. (2016) [1] studied the effects of oven drying on chemical composition of ginger and concluded that during drying of ginger rhizomes, not only the moisture of the produce was affected but other nutritional parameters were also affected. The oven drying in removing sufficient moisture and also enhanced some nutritional parameters of the produce ginger.

Satwase *et al*. (2013) [21] stated that protein, carbohydrate, fat, fibre and ash content of drumstick leaves were increased when subjected to sun, shade, cabinet and oven drying.

3.4.3 Mineral composition of processed ginger rhizome

Mineral content of dried ginger rhizome is essential in justifying its food value. Phosphorous, calcium, iron, magnesium, zinc, copper and manganese are the minerals of interest in current study. Minerals play a key role in various physiological functions of the body especially in the building and regulation processes. The results pertaining to mineral content of dried ginger rhizome are presented in Table 6.

Table 6: Effects of processing on mineral composition of dried ginger rhizome

S. No.	Mineral composition (mg/100g)	Surat method	Mulbar Method	MPKV, Method	SE±	CD at 5%
1	Calcium	78.62	81.30	79.95	0.817	2.531
2	Phosphorus	154.31	153.68	156.22	1.629	5.045
3	Magnesium	166.09	168.65	169.05	1.311	4.060
4	Iron	2.23	2.35	2.41	0.218	0.667
5	Zinc	0.87	0.89	0.92	0.065	0.201
6	Copper	0.60	0.64	0.61	0.047	0.145
7	Manganese	2.06	2.23	2.12	0.350	1.083

*Each value is average of three determinations

The data presented in table 6. revealed the effects of different processing methods on mineral composition of dried ginger rhizome. It was observed that ginger sample dried by MPKV method is significantly superior over ginger sample processed by surat and mulbar method. The calcium content of sample dried by mulbar method is more as compare to other samples i.e. 81.30 mg/100g. The calcium content of ginger sample dried by surat and MPKV method is 78.62 and 79.95 mg/100g. Respectively. Drying of ginger result in increase in calcium content. According to Perez-Lopez *et al*. (2002) [16], the calcium content was affected by temperature, calcium chloride concentration and treatment time.

The phosphorus contributes in bone formation, energy metabolism and nucleic acid metabolism. The sample processed by MPKV method got highest value for phosphorus i.e 156.22 mg/100g. The ginger processed by surat and mulbar method had phosphorus content 154.31 and 153.68 mg/100g respectively. The magnesium content of ginger samples dried by surat, mulbar and MPKV method are 166.09, 168.65 and 169.05 mg/100g respectively. The retention of good proportion of magnesium is observed by MPKV method. The increase in magnesium content is probably be due to the heating effect of the drying minerals which do not escape/vaporize and as such higher values in magnesium were seen (Liman *et al*., 2014) [12].

The iron content of ginger samples dried by surat, mulbar and MPKV method are 2.23, 2.35 and 2.41 mg/100g respectively. The zinc content of ginger samples dried by surat, mulbar and MPKV method are 0.87, 0.89 and 0.92 mg/100g respectively. The copper content of ginger samples dried by surat, mulbar and MPKV method are 0.60, 0.64 and 0.61 mg/100g respectively. The manganese content of ginger samples dried by surat, mulbar and MPKV method are 2.06, 2.23 and 2.12 mg/100g respectively. The sample dried by MPKV method found significantly superior than ginger dried by surat and mulbar method with respect to phosphorus, magnesium, iron and zinc. The increase or decrease of micronutrient of dried sample may be attributed to the removal of water molecule by drying.

Sangwan *et al*. (2014) [20] studied nutritional composition of ginger powder prepared by different drying methods i.e. sun drying, solar drying, oven drying and microwave drying. Hassan *et al*. (2007) [9] studied the effect of drying method on nutrients and non-nutrients composition of leaves of *Gynandropsis gynandra* (*Capparaceae*) and observed significant increase of mineral elements upon drying with exception of sodium.

Conclusion

In the light of present investigation it was concluded that ginger contained macro and micro nutrient. The ginger sample processed by MPKV rahuri method is found superior than ginger sample processed by surat and mulbar method with respect to protein, fat and fiber content and minerals like phosphorus, magnesium, iron and zinc.

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