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Evaluation of Nutritional and Mineral Content of Dehydrated Ginger *(Zingiber officinale)*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MA and MR design a hypothesis for research and planned methodology to reach the conclusion. Authors NB, MB, SM and MR took the responsibility in execution of the experiments, data management and reporting. Authors MA, MB, SM and MR took the accountability in logical interpretation and presentation of the results. Authors MA, MB and MR wrote the whole body of the manuscript. Authors MR, MB and MA reviewed the article before submission not only for spelling and grammar but also for its intellectual content. All authors read and approved the final manuscript.

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ABSTRACT

This study was executed to produce dehydrated ginger powder using four different drying methods *viz*. sun, oven, mechanical and microwave along with their nutritional, mineral content and sensory quality evaluation. Microwave dried powder contained highest moisture content (7.10±0.04%) and was significantly different to other drying methods. Protein, fat, ash and crude fiber contents ranged from (6.10 ± 0.05 to 6.78 ± 0.07%), (1.01 ± 0.16 to 1.42 ± 0.25%), (3.21 ± 0.12 to 4.07 ± 0.10%) and (3.76 ± 0.13 to 4.88 ± 0.12%) respectively. K and Ca contents ranged from (20.45 ± 0.06 to 26.35 ± 0.07 mg/100 g) and (108.64 ± 0.09 to 188.62 ± 0.07 mg/100 g), respectively. Though some values were significantly different (*P<0.05*) under different drying conditions, the analyzed results showed that the produced ginger powder retained a good nutritional profile, minerals and sensory quality.

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Keywords: Drying methods; nutritional composition; mineral content; dehydrated ginger powder; sensory quality.

ABBREVIATIONS

GP : Ginger powder
OD : Oven dried
SD : Sun dried
MWD : Microwave dried
MD : Mechanical dried

1. INTRODUCTION

Ginger *(Zingiber officinale)* is one of the oldest spice with a distinct flavor and pungency. It is a flowering plant and perennial herb from the family Zingiberaceae that is widely used as food flavoring and also as a natural source of functional foods and nutraceuticals. This plant is used around the whole world as a spice in dried and fresh conditions for enhancing the flavor, taste and to make spicy and pungency to the meal [1]. This plant containing many bioactive compounds such as phenolic, flavonoids, vitamins, carotenes and therefore possesses health promoting properties [2]. This herb is used in herbal medicine for prevention of some diseases [3]. It also uses as masala (*i.e*. pickles, cookies, marmalade), flavoring substances in confectionery, bakery products, and alcoholic and non-alcoholic beverage [4]. Postharvest management of ginger is not well developed, hence proper processing and storage reduces the spoilage of this plant [5]. It is necessary to explore alternative methods for preserving and processing it industrially. Dehydrated ginger powder can be a substitute product of fresh ginger and preserve its freshness for a long period. It can also be considered as a processed food product for ready to use in restaurants and homes [6]. It is used in different culinary preparations, seasoning ingredients, masala preparations, ginger tincture, ginger liniment, and salve [7]. For practical benefits and longer shelf life, the dried ginger powder (GP) may become an effective solution for processors to make it as a value added product and spice powder for off-seasons. There are different drying methods including sun drying, vacuum drying, mechanical drying, oven drying, and Microwave drying [8].

Therefore, the objective of this study was evaluating four different drying methods *viz*. oven, sun, mechanical, and Microwave drying on nutritional, minerals content, sensory quality of dehydrated ginger powder.

2. STUDY DESIGN

2.1 Materials Procurement

Ginger *(Zingiber officinale)* rhizome were collected from local market for this study. All chemicals and reagent used in this study were procured from sigma aldrich, Bangladesh.

2.1.1 Dehydrated GP preparation

Ginger rhizome were cleaned with tap water. For extending shelf life and color cleaned ginger were soaked in boiling water for 25 sec. Then immersed in 0.3% Potassium metabisulphite (KMS) solution for 15 minutes at room temperature [9]. Treated ginger were cut into 3-5 mm slices and dehydrated in four different drying methods.

i. Sun drying – Gingers were dehydrated in open hot sunlight.
ii. Oven drying - Gingers were dehydrated at (50 ±5) ˚C for 6-8 hours.
iii. Mechanical drying - Gingers were dehydrated in hot air mechanical dryer.
iv. Microwave drying - Gingers were dehydrated in Microwave of 800W for 5-10 minutes.

Dehydrated ginger slices were ground using a grinder for making fine powder. Prepared GP was stored at 4°C in airtight polyethylene bag for further analysis.

2.2 Methods of Analysis

All experimental parameters were conducted at ambient temperature and carried out in three replications.

Fig. 1. Flow chart for producing dehydrated ginger powder

Sliced ginger **Sun dried** **Oven dried** **Mechanical dried** **Microwave dried**

Fig. 2. Dehydrated ginger powder

2.2.1 Moisture estimation

Moisture content was estimated following AOAC,2005 method [10]. 5 g GP was taken in pre-weighed petri dish and dried in oven maintaining temperature (105±5)°C until a constant weight was obtained. Moisture content was calculated following this formula.

Moisture (%)= [{(Initial wt. of sample – Dried wt. of sample) ÷ Initial wt. of sample} ×100]

2.2.2 Ash content estimation

Ash content was estimated following AOAC,2005 method [10]. 5g sample was taken into pre-weighed crucible and heated over a bunsen burner until the sample completely burnt. Then the crucible was taken into muffle furnace and burnt for 5 hours at 550°C. The crucible was kept into a desiccator for cool. The ash content was calculated following this formula.

Ash (%) = [(Wt. of ash ÷ Wt. of sample taken) ×100]

2.2.3 Protein content estimation

Protein content of GP was estimated following Kjeldahl Method [11]. This method was involved in digestion, distillation and titration. 0.5 g sample and 0.2 g digestion mixture was taken in Kjeldahl tube then 20 ml 98% sulfuric acid added in tube. The mixture was digested with speed digester at 420°C for 4 hours. Digested solution entered into distillation chamber. After distillation the solution was titrated with 0.1N hydrochloric acid. After estimating the nitrogen content then that was multiply with 6.25 as factor. Protein content was estimated following this formula.

Nitrogen (%) = [(Burette reading × Normality of acid × 1.4007) ÷ Sample weight]

Protein (%) = [Nitrogen content (%) × 6.25]

2.2.4 Fat estimation

Crude fat was estimated following soxlet method approved by AOAC, 2005. 5 g sample was taken in cellulose extraction thimble [10]. Thimble was taken into soxlet extraction column of the fat analyzer. Boiling flask (250 ml) was filled with 150 ml (60-40) petroleum ether and placed under extraction column according to the corresponding thimble. Thimble was dipped into solvent for 3 hours at 90°C. Then the thimble was raised above from the solvent and set for 30 minutes. The thimble was removed carefully and petroleum ether solvent was collected from the top of the container and preserve for reuse. Boiling flask was taken in oven for blowing out extra petroleum ether solvent. Then the crude fat was weighed. The fat content was calculated using this formula.

Fat (%) = [(Wt. of fat ÷ Wt. of sample) × 100]

2.2.5 Crude fiber estimation

Crude fiber content of defatted dry sample was estimated by using AOAC,2005 method [10]. About 2.5 g defatted dry sample was taken for fiber analysis. The sample is allowed to boil with 1.25% dilute H_2SO_4, washed with water, further boiled with 1.25% dilute NaOH and the remaining residue after digestion was taken as crude fibrate residue was taken in a furnace and digest at 600 °C. Crude fiber was estimated following formula.

Crude fiber (%) = [(Loss in weight on ignition ÷ Weight of the sample) × 100]

2.2.6 Carbohydrate estimation

Carbohydrate content was estimated by calculation using the difference method. The

constituents of food *i.e*. protein, fat, moisture and ash were determined individually and summed, then the sum was subtracted from the total proximate percentage of food. This is referred to as total carbohydrate by difference.

Total Carbohydrate (%) = [100 − %(Protein + Fat + Moisture + Ash + Fiber)]

2.2.7 Energy value calculation

The energy value of the samples was determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9 [12].

Food energy (Kcal/100g) = [(%Crude protein × 4) + (%Fat content × 9) + (%Carbohydrate × 4)]

2.2.8 Estimation of minerals content

Mineral contents of dehydrated ginger powder were estimated following Flame photometric method [13] and Atomic absorption spectrophotometric method [14]. About 2.0 g dry sample was taken in muffle furnace and burnt to ash at 600°C. Ash sample was taken in into a volumetric flask. It was digested with 7 ml Nitric acid and 2 ml H_2O_2 two times for 15 minutes at 180°C in 1200-Watt radiation. Sonication was done by the ultra sound system for mixing and to remove bubbles from the digested sample and then it was filtered with filter paper. The solution was made up-to a certain volume. The sample was then placed into the flame mode of Atomic absorption spectrophotometer at about 2300°C to 2600°C temperature. The flame mode includes dissolving, vaporization, Atomization and ionization. This method typically used for determinations of minerals in mg/100g. The concentrations of minerals were determined by their calibration curves.

Amount per 100 g = [(Concertation × Dilutions × 100) / weight of sample]

2.3 Sensory Quality

The sensory quality of the produced dehydrated ginger powder in respect of color, flavor, appearance and texture was judged by panelists using 9-point hedonic scale. Where 9= Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5= Neither like nor dislike, 4=Dislike slightly, 3=Dislike moderately, 2=Dislike very much, 1=Dislike Extremely.

2.4 Statistical Analysis

All the statistical analyses for this study were done by SPSS 22.0 version. Data values were expressed as a percentage and mean± SD. One-way ANOVA with suitable Post hoc analysis was done to figure out the significant/non-significant difference of the mean value. The findings were considered as statistically significant, if $p < 0.05$.

3. RESULTS AND DISCUSSION

The data of prepared dehydrated powder using four drying methods are represented in Table 1. SD powder contained (5.12±0.15%) moisture, (3.82±0.09%) ash, (1.19±0.21%) fat, (6.54±0.09%) protein, (4.76±0.10) fiber, (78.57±0.12) carbohydrate. Similar results were also observed in other studies [15]. Whereas OD powder contained moisture (4.07±0.12%), ash (3.42±0.08%), fat (1.01±0.16%), protein (6.78±0.07%), fiber (3.76±0.13), carbohydrate (80.96±0.17). MD powder contained moisture (4.37±0.14), ash (4.07±0.10), fat (1.21±0.21), protein (6.10±0.05), fiber (4.11±0.06), carbohydrate (79.34±0.11) and MWD powder contained moisture (7.10±0.04), ash (3.21±0.12), fat (1.42±0.25), protein (6.22±0.03), fiber (4.88±0.12), carbohydrate (77.17±0.22). Similar results for OD, MD and MWD powder were reported in another studies [16]. Energy content for SD, OD, MD and MWD results were (351.15±0.11 kcal/100 g), (360.05±0.15 kcal/100 g), (355.85±0.10 kcal/100 g) and (346.34±0.21 kcal/100 g) respectively. Similar finding was observed in this study [17].

Table 1. Proximate composition of dehydrated ginger powder

Parameters	Sun dry	Oven dry	Mechanical dry	Microwave dry
Moisture(%)	5.12±0.15	4.07±0.08*	4.37±0.14*	7.10±0.04*
Ash(%)	3.82±0.09	3.42±0.08	4.07±0.10*	3.21±0.12*
Fat(%)	1.19±0.21	1.01±0.16	1.21±0.21	1.42±0.25
Protein(%)	6.54±0.09	6.78±0.07*	6.10±0.05*	6.22±0.03
Crude fiber(%)	4.76±0.10	3.76±0.13*	4.11±0.06	4.88±0.12

*Values are means of triplicates ±SD. Values with *asterisk indicates in a row significantly different from sun dried powder, where P<0.05*

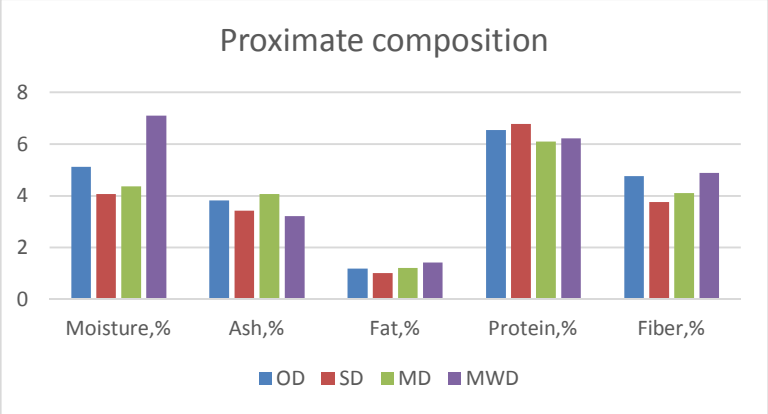

Fig 3. Proximate composition of dehydrated ginger

Fig. 3 shows the comparative trends of the major nutrient composition observed by proximate analysis of four drying methods. OD method is effective in removing moisture than another drying method. Increasing moisture reduce the shelf life of processed product [18] Protein content for OD was higher than other methods but lower in MD. No significant difference P<0.05 was observed in fat content result. This finding was corresponded with OD and SD powder reported by Ajay et al. [19]. Protein content for OD powder was higher than other methods but lower amount in MD powder. No significant difference(P<0.05) was noticed in SD and MWD. Similar findings for protein content results have been reported earlier in other studies [20]. Cruder fiber for OD powder was significantly lower than other drying methods but higher amount crude fiber was estimated in MD powder. A good amount of fiber content benefits for indigestion problem [21].

From the data Table 2, OD carbohydrate content was significantly higher and lower amount in MWD powder. The result indicates that dehydrated ginger powder contains a good amount of carbohydrate content. Highest energy content was observed in OD powder and lowest in MWD powder. According to this data ginger powder had a good energy profile, so it can be graded as added product in cookies, pickles and other products.

Table 2 is the data of essential minerals that were estimated in this study. SD powder contained Na (4.19±0.02 mg/100 g), K (25.25±0.04 mg/100 g), Fe (4.65±0.04 mg/100 g), Ca (151.24±0.07 mg/100 g) and Zn (11.45±0.03 mg/100 g). Whereas OD powder contained Na (6.58±0.03 mg/100 g), K (21.65±0.05 mg/100 g), Fe (4.23±0.05 mg/100 g), Ca (139.85±0.08 mg/100 g), Zn (11.20±0.04 mg/100 g). MD powder contained Na (6.22±0.04 mg/100 g), K (26.35±0.07 mg/100 g), Fe (2.59±0.07 mg/100 g), Ca (108.64±0.09 mg/100 g), Zn (9.13±0.06 mg/100 g) and MWD powder contained Na (4.27±0.02 mg/100 g), K (20.45±0.06 mg/100 g), Fe (3.95±0.06 mg/100 g), Ca (188.62±0.07 mg/100 g), Zn (9.01±0.08 mg/100 g). Ca content of dried powder is the highest essential mineral content in this study. Higher amount K content was found in MD powder and lower amount in MWD powder. The lowest mineral content in this study are Fe and Zn. Similar findings were also observed in Famurewa et al. [22]. Clearly illustrate that Ca content was the highest among estimated minerals and followed by K content. Ca is one of the most important minerals for human health followed by K mineral. Na and K is responsible for maintaining electrolyte in human body. All dehydrated powder contained the least quantity of Sodium, Iron and Zinc but good amount of Calcium and potassium.

Table 2. Energy and carbohydrate of dehydrate ginger

Parameters	Sun dry	Oven dry	Mechanical dry	Microwave dry
Carbohydrates,g/100 g	78.57±0.12	80.96±0.17*	79.34±0.11	77.17±0.22*
Energy.Kcal/100 g	351.15±0.11	360.05±0.15*	355.85±0.10	346.34±0.21*

*Values are means of triplicates ±SD. Values with *asterisk indicates in a row significantly different from sun dried powder, where P<0.05*

Table 3. Mineral contents of dehydrated ginger powder

Minerals	Sun dry	Oven dry	Mechanical dry	Microwave dry
Na(mg/100 g)	4.19±0.02	6.58±0.03*	6.22±0.04*	4.27±0.02
K(mg/100 g)	25.25±0.04	21.65±0.05*	26.35±0.07*	20.45±0.06*
Fe(mg/100 g)	4.65±0.04	4.23±0.05*	2.59±0.07*	3.95±0.06*
Ca(mg/100 g)	151.24±0.07	139.85±0.08*	108.64±0.09*	188.62±0.07*
Zn(mg/100 g)	11.45±0.03	11.20±0.04*	9.13±0.06*	9.01±0.08*

*Values are means of triplicates ±SD. Values with *asterisk indicates in a row significantly different from sun dried powder, where P<0.05*

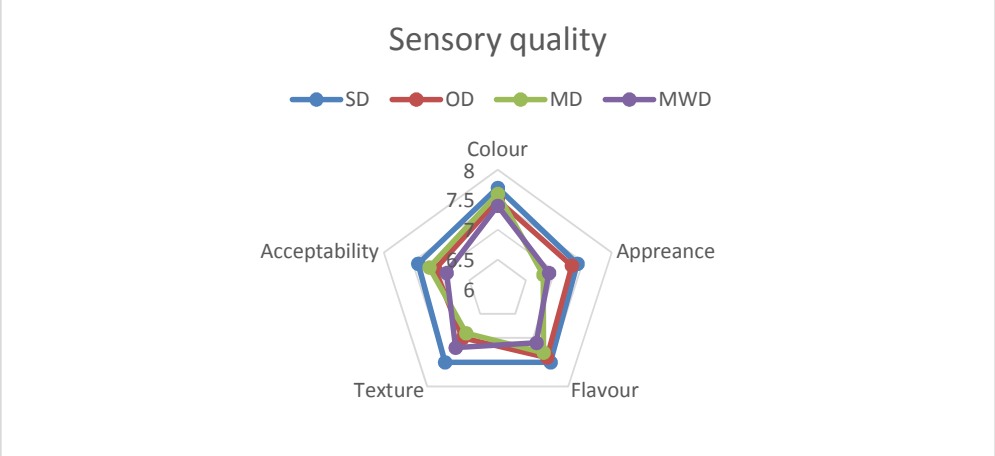

Fig. 4. Sensory quality of dehydrated ginger powder

Fig. 4 showed the sensory quality of the dehydrated ginger powder using four drying methods. Sensory quality of dehydrated ginger powder using four drying methods were found to be acceptable by the panelists. SD powder scored highest mean score in all attributes than other dried powder. In colour attribute SD powder scored (7.7±0.03) maximum and MWD powder scored (7.4± 0.05) minimum. In flavor attribute SD powder scored (7.5±0.01) and MWD powder scored (7.1± 0.04). In acceptability attribute SD powder scored (7.4± 0.08) maximum and MWD powder scored (6.9± 0.01) minimum. Mean scores for sensory quality parameters indicated that produced dehydrated ginger powder using four drying of methods were in the range of acceptable range and good sensory quality.

4. CONCLUSION

In consideration of four drying methods nutrients and mineral contents were estimated. The present study besides adding benefits to better understanding food chemistry contributed to the socio-economic and nutritional choice of the consumers. From the above study we can conclude that ginger powders prepared using sun, oven, mechanical and microwave drying methods have good nutritional and mineral contents. When market rates of ginger are fluctuating, we can make powder of it and can use in many culinary preparations in the off-session also. It saves our precious time, money and energy.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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