Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

NUTRITIONAL COMPOSITION AND FUNCTIONAL GROUPS PROFILE OF GINGER RHIZOME: A COMPARATIVE STUDY ON GINGER FROM VARIOUS ORIGINS GROWN IN PAKISTAN

MADIHA JAVID
Lecturer, Department Home Economics, Government College Women University, Faisalabad.
Persuing Doctorate Degree, Human Nutrition and Dietetics, National Institute of Food Science and Technology, University of Agriculture Faisalabad. Email: madihajavid14@gmail.com

RIZWAN SHUKAT
Assistant Professor, National Institute of Food Science and Technology, University of Agriculture Faisalabad. Email: rizwanuaf@hotmail.com

MIAN KAMRAN SHARIF
Associate Professor, National Institute of Food Science and Technology, University of Agriculture Faisalabad. Email: mks@uaf.edu.pk

MUHAMMAD NAEEM FAISAL
Assistant Professor, Institute of Physiology and Pharmachology, University of Agriculture Faisalabad. Email: m.naeem.faisal@uaf.edu.pk

Abstract

Ginger (*Zingiber officinale*) belongs to the Zingiberaceae family of flowering plants, which originated in South-East Asia and has long been a popular culinary ingredient. The study was carried out to investigate the nutritional composition and functional group profile of ginger rhizome in different varieties of ginger grown in Pakistan. Samples of four varieties each originated from Thailand, Turkey, China and India, collected from Ayub Agricultural Research Institute Faisalabad, were dried and subjected to proximate, mineral, functional group and colour analyses. Moisture, ash, crude fat, protein, crude fiber and nitrogen free extract (NFE) were found to range between 6.03-8.41%; 4.43-6.63%; 4.07-7.08%; 5.80-9.46%; 5.14-6.37% and 64.87-69.39%, respectively. Calcium, magnesium, zinc and copper in the ginger varieties ranged between 145.42-172.67 mg/100 g, 412.75-595.92 mg/ 100 g, 1.64-3.62 mg/100 g and 0.82-4.19 mg/100 g, respectively. Fourior Transform Infrared Spectroscopy (FTIR) spectra of ginger powders have strongly evidenced the presence of -OH (alcoholic group) and benzene rings (phenolic groups) with more phenolic compounds depicted in Thailand originated variety. Colour lightness range of the four ginger varieties were; L*: 25.47-58.51; a*: 5.06-7.21; b*: 15.21-23.27.

Index Terms: Ginger, Rhizome, Chemical Composition, Proximate Analysis, Minerals, FTIR, Functional Group, Colour Detection.

1. INTRODUCTION

Ginger, a common herbal spice as well as medicinal plant that has been originated from Asia, technically known as *Zingiber officinale*, is being grown for centuries in various parts of the world [1]. Carbohydrates, fats, proteins, fibers, minerals and vitamins are also found in ginger in varying concentrations [2]. Numerous nutrients, including carbs, proteins, fats, minerals, and vitamins, as well as health-promoting phytochemicals, primarily phenolic compounds and ginger essential oil, have been shown to be present in ginger.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

Ginger also demostrates a wide range of biological activities, including strong antibacterial and antioxidant properties [3].

The rhizome of ginger is a rich source of macro and micro minerals such as calcium, potassium and phosphorus those are known for health benefits due to their role in regulating numerous physiological functions in our body. Ginger also stores abundant organic components such as lipids, vitamins, organic acids, phenolics, terpenes and polysaccharides [4]. The composition of nutrients and active compounds found in ginger rhizome determine its bioactivity and depends on the geographical origin where it has been cultivated, post-harvesting handling, processing, temperature and dehydrating conditions [5]. Ginger is most commonly used in cookery, as a condiment, and in medicine all over the world due to its distinctive taste and aroma [6] and potential antioxidant, anticancerous and antimicrobial activities [7]. Ginger is one of the functional foods which contains bioactive phenolic compounds including gingerol, zingerone, shogaol and paradol that exhibit antiinflammatory, antioxidant, antiarthritic, antitumor, hypolipidemic and analgesic properties [8].

Ginger is a good source of micronutrients which are essentially to be present human diet for sustaining health. It contains rich amounts of vitamins notably β-carotene, ascorbic acid, and minerals such as phosphorous, calcium, iron, copper, zinc, manganese and chromium [9]. The essential oils present in the ginger impart their effect to enhance the flavour of the product. The present study was carried out to investigate the nutritional and functional group profile of various ginger varieties grown in Pakistan.

2. RELATED WORK

Many researchers have worked upon proximate composition, mineral profiling and other nutrients' concentration found in ginger in its fresh form and dried and prepared in different ways, harvested and collected in various places of the world. Data of some of the studies have been gathered and reviewed for comparison with the recent research results. Proximate analysis of any food substance provides information overly about its macro and micro nutrient *i.e.* moisture, ash, crude protein, crude fat, crude fiber and nitrogen free extract. Various studies in the past have been conducted to determine the proximate composition of ginger rhizome. The concentration of different nutrients has been reported differently by early researchers as they may vary with the geographical location of harvesting the crop, type of soil, fertilizers and other factors [4]. Proximate values of dried ginger rhizome found in early studies have been reported by early researchers. The moisture content of dried ginger rhizome has been reported in various studies ranging between 3.6% [10] and 15.2% [11]. Amount of ash in ginger powder has been found to range from a minimum of 1.74% [12] to maximum reported 3.85% [11]. Fat content in ginger was found varying in different studies: 0.78 g [10]; 3.72 g [11] and 5.03 g [12] per 100 g of dried rhizome. Quantity of crude fiber in ginger powder was observed to be varying between 5.4% using different drying methods [10] and 76.4% determined in oven dried ginger [12]. Crude protein content of dried ginger powder in previous studies was reported to be varying between 5.0% [10] and 7.88% [12].

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

The ginger rhizome holds a good amount of macro and micro minerals including potassium, phosphorus and calcium [4]. Though minerals are not energy sources, yet they are essential for controlling physiological and cellular metabolism. The body uses trace metals as coenzymes to regulate metabolic reactions and to maintain pH and osmotic regularity [13]. Foods sourced from plants have the ability to provide all of the needed minerals for human nutrition. In general, a person's quality of life can be impacted by either an excessively high or low concentration of trace elements in their diet. A wide range of mineral elements content has been observed from the data of previous findings. On account of calcium, as low as 0.4 mg [14] and as high as 88.4 mg [11] was found in 100 g ginger on dry basis. Regarding iron, the lowest reported value in the reviewed literature was seen to be 0.32 mg/100 g of dry ginger [15], whereas the highest concentration found was 80.0 mg/100 g dried ginger rhizome [12]. Very few studies have reported the potassium content findings in ginger. Rachkeeree *et al.* [15] has found 737 mg/100 g whereas Kefale *et al.* [16] has reported potassium content of 330.4 mg/100 g in ginger on dry basis.

Functional groups present in a molecule are determinants of the chemical properties of compound and of the material they are sourced from. Hence, functional groups identification is crucial in order to know the bioactivity of some plant matter. To discover functional moieties, present in a substance, the analytical technique which is being practiced for many years is FTIR (Fourier Transform Infrared) Spectroscopy [17]. FTIR analysis uses infrared light to pass through the test material in order to scan and observe its distinct chemical features.

3. PROPOSED METHODOLOGY

3.1 Procurement of Materials

Four samples of different lines/varieties (later on will be called “variety”) of ginger rhizome: Thailand-18004; Turkey-19006; China-AARI23 and India-17002, were collected from Vegetable Research Department, Ayub Agriculture Research Institute (AARI) Faisalabad, Pakistan. Fresh ginger was subjected to dehydration followed by grinding for preparation of fine powder. All varieties of ginger were washed and scrubbed under running water. Any damaged or bruised areas were cut away.

Ginger was dried with a clean paper towel. Skin of the washed ginger was removed with a knife. Each variety was weighed before and after peeling and trimming to calculate the peeling loss. Thin slices (about1/8”) were made out of the peeled ginger varieties and placed on separate mesh trays fitted in the tray drier (R-5A; Harvest Saver; USA) available at Fruits and Vegetable Laboratory, NIFSAT, UAF.

The cut ginger slices were subjected to dehydration at 55^{o}C for approximately 13 hours. The dehydrated slices of each variety of ginger were weighed and milled with the help of a mechanical grinder into fine powder. The ginger powder was stored in airtight jars for further analyses/processing.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

3.2 Proximate Analysis

Ginger powder of each variety was subjected to proximate analysis to determine moisture, ash, crude fat, crude protein and crude fiber content using the methods described by AOAC [18]. Every procedure was performed in triplicate (n=3).

3.3 Mineral Analysis

Ginger powder of each variety was used to estimate macro-minerals (calcium and magnesium), micro-minerals (zinc and copper) and trace mineral (chromium) by using flame photometer [18]. Wet digestion of powdered samples was done to prepare the samples for mineral analysis by removing all other nutrients from the sample except soluble minerals. Wet digestion helps to decompose the organic matrix of the plant material making it easier for mineral analysis. Digestion of sample was done by using nitric acid (HNO_3) and perchloric acid ($HClO_4$). 1.0 g ginger powder was taken and transferred to a 100 mL Kjeldhal digestion flask. With the help of graduated cylinder, 20 mL of conc. nitric acid (HNO_3) was added and heated at low temperature for 15 min. Temperature was slightly increased and contents in the flask were heated for further 30 min. When fumeless, 5 mL of perchloric acid ($HClO_4$) was added into the flask drop by drop using a dropper pippet. The contents were heated firstly at low temperature and then at high temperature till the volume remained 1 – 2 mL. The sample was let cool down, filtered and diluted with distilled water to make up a 100 mL volume. The sample was ready to run through a spectrophotometer/flamephotometer to determine mineral contents. Calcium, magnesium, zinc, copper and chromium contents in ginger powder wet digested samples were determined by using Atomic Absorption Spectrophotometer (Z-8200; Aas Hitachi; Japan) available at Central Hi-Tech Laboratory UAF, following the respective procedure mentioned in AOAC [18]. Standard values of each mineral on instrument were obtained by running solutions of known strengths (1000 mg/L) through flame photometer. Concentration of each mineral was given in part per million (ppm) which was then converted into mg/100 g via dilution factor (100).

3.4 FTIR Spectroscopic Analysis

To identify the functional groups, present in ginger powder obtained from different varieties, the Fourier Transform Infrared (FTIR) spectroscopy was carried out. Pellets of each sample were prepared using potassium bromide (KBr). Small quantities of ginger powder of each variety were finely ground with completely dried KBr and pellets were prepared by compressing the mixture under vacuum. At room temperature (25±2°C), data were acquired in transmittance mode with 4.0 cm^{-1} resolution within the spectrum range of 4000–400 cm^{-1} using the Cary 630 FTIR; Agilent Technologies; California, available at the Department of Chemistry, UAF. Bands were identified by cross-referencing the recorded data with previously reported assignments [19].

3.5 Colour Analysis

For the measurement of colour reflectance of the powdered ginger samples, a chroma meter (Minolta CR-400; Konica; Japan) was used available at Laboratory, NIFSAT, UAF.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

The operating instructions of the equipment were followed to obtain measurements. The sample was uniformly spread over a clean, dry surface with a smooth, white background and the equipment was positioned a few millimetres from the powdered sample's surface in order to capture the colour. The parameter measured included: L∗ (lightness); a∗ (red saturation) and b∗ (yellow saturation). Lightness was recorded in range from 0 – 100: 0 for black; 100 for white. Red and yellow saturation indices were measured in negative or positive values term: (+a∗ = red; -a∗ = green); (+b∗ = yellow; -b∗ = blue) (Jayathilake *et al.*, 2022).

3.6 Statistical Analysis

The inter-group variations of different trials were analyzed by ANOVA using Minitab-17 statistics software. Post hoc Tukey's test was conducted at 95% confidence level to identify if the difference between samples was significant.

4. RESULTS AND DISCUSSION

Samples of fresh ginger from four varieties named Thailand-18004, Turkey-19006, China-AARI23 and India-17002 were collected from the AARI Vegetable Research Department. The rhizomes' weights were recorded before and after peeling and after complete dehydration. Moisture content in each genotype was measured by subtracting the dried weight from the fresh weight. Mean weight (%) values ± SD have been presented in Table 1.

Table 1: Dry weight (%) and moisture (%) of fresh ginger

Ginger Sample	Peeling loss	Peeled rhizome	Dry weight	Moisture
Thailand-18004	9.00±0.15^{c}	91.00±0.15^{a}	17.18±0.79^{ab}	73.82±0.84^{ab}
Turkey-19006	11.47±0.23^{b}	88.53±0.23^{b}	12.32±0.49^{c}	76.21±0.29^{a}
China-AARI23	14.30±0.43^{a}	85.70±0.43^{c}	15.95±1.79^{b}	69.75±1.68^{c}
India-17002	9.74±0.28^{c}	90.25±0.28^{a}	18.99±0.86^{a}	71.26±0.65^{bc}

Values are mentioned as mean±SD; n=3; Values in a column not sharing a letter differ significantly with each other (p<0.05).

4.1 Peeling Loss

After peeling, the mean weight of peeled rhizomes was recorded to be 91.00±0.15 g, 88.53±0.23 g, 85.70±0.43 g and 90.25±0.28 g out of 100 g for Thailand-18004, Turkey-19006, China-AARI23 and India-17002, respectively. The peeling loss was calculated as Thailand-18004: 9.00±0.15, Turkey-19006: 11.47±0.23, China-AARI23: 14.30±0.43 and India-17002: 9.74±0.28%. There was a significant difference between peeling loss of different varieties. Fig.1 illustrates that China-AARI23 endured the highest peeling loss as compared to all other varieties. Thailand-18004 and India-17002 endured the least waste as peels.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

4.2 Dry Weight

After complete dehydration, the recorded weights of the dry matter from the four ginger varieties were found as Thailand-18004: 17.18±0.79, Turkey-19006: 12.32±0.49, China-AARI23: 15.95±1.79 and India-17002: 18.99±0.86 percent. The dry matter yield of different samples of ginger varied significantly. From Table 1, it can be elucidated that India-17002 ginger gave the best dry yield (18.99%) which was slightly more than Thailand-18004 (17.18%). Turkey-19006 ginger, on the other hand gave a significantly lower count of dry matter of all other varieties *i.e.* 12.32%. Jan *et al.* [8] reported that a ginger sample of 3 Kg from a local market in Srinagar (J&K) India had given a dry matter yield of 305.31g (10.17%) rendering 630 g waste as fresh peels that is falling below the whole range reported in the current study.

4.3 Moisture Content

Moisture content in the fresh rhizome was marked to be ranging between 69.75% and 76.21% (Table 1). A significant difference was found to exist among the varieties ($p<0.05$). Turkey-19006 possessed the highest moisture content in its fresh rhizome (76.21±0.29%) hence yielded the least dry matter with moderate amount of peeling loss as compared to all other varieties. China-AARI23, on the other hand, contained the least moisture content (69.09±2.29%) but owing to great peeling loss, could only yield a moderate amount of dry matter. However, Thailand-18004 despite showing a large value of moisture content (73.82±0.84%) could yield extraordinarily good amount of dry matter owing to the least peeling loss. More the moisture in the fresh rhizome and peeling loss combined, lesser will be the dry matter yield of ginger and vice versa (Fig.1).

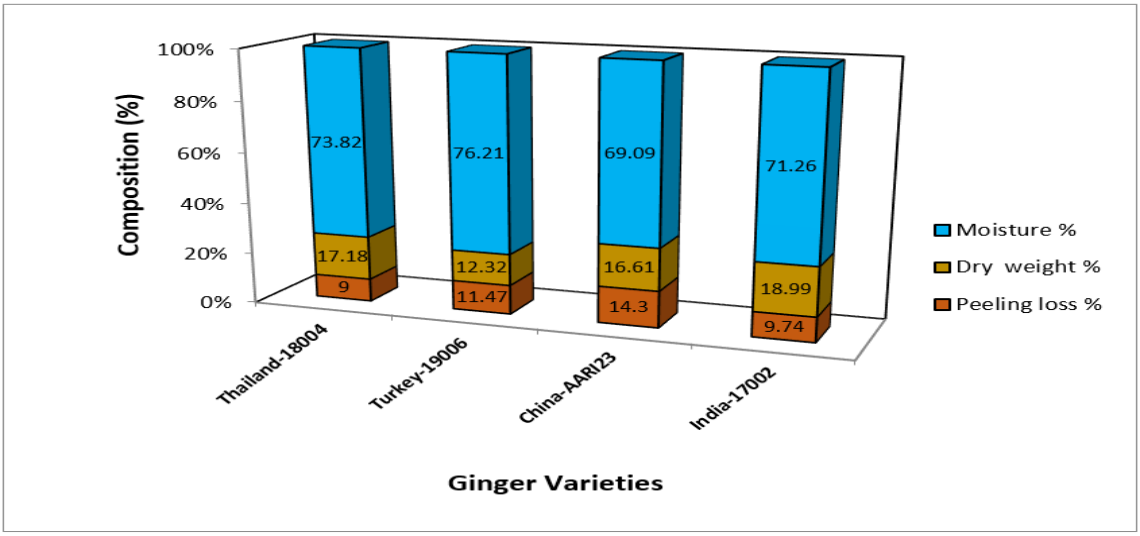

Figure 1: Dry weight/moisture content of fresh ginger samples

4.4 Proximate Composition

Powdered samples of different ginger varieties were subjected to proximate analyses to study their moisture, ash, crude fat, crude protein, crude fiber and NFE contents. The

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

mean ± SD values of all parameters for each variety are expressed in percentage and have been recorded in Table 2. Fig.2 represents a pictoral comparison among proximate composition of the four varieties.

Table 2: Proximate composition (%) of dried ginger

Ginger Sample	Moisture	Ash	Crude Fat	Crude Protein	Crude Fiber	NFE
Thailand-18004	8.41±0.34^{a}	5.43±0.21^{b}	7.08±0.06^{a}	5.80±0.28^{b}	6.22±0.28^{a}	67.05±0.80^{b}
Turkey-19006	6.03±0.32^{c}	6.63±0.06^{a}	6.78±0.21^{a}	9.46±0.26^{a}	6.21±0.19^{a}	64.87±0.33^{c}
China-AARI23	7.29±0.13^{b}	6.26±0.21^{a}	5.66±0.20^{b}	8.70±0.60^{a}	5.14±0.06^{b}	66.93±0.94^{b}
India-17002	7.01±0.10^{b}	4.43±0.15^{c}	4.07±0.05^{c}	8.72±0.97^{a}	6.37±0.12^{a}	69.39±0.84^{a}

Values are mentioned as mean±SD; n=3; Values in a column not sharing a letter differ significantly with each other (p<0.05).

4.4.1 Moisture

Moisture in a food item is inversely proportional to its shelf life, and amount of moisture in a food product can greatly affect its sensory attributes especially taste and texture. Moisture is most commonly measured by gravimetric oven method which is a destructive method (Huang *et al.*, 2014). In the current study the Hot Air Oven was used for moisture analysis keeping the temperature at 50^{o}C.

Mean moisture content of dried ginger in the recent work has been found to range from 6.03% to 8.41%. A significant difference among all the varieties has been identified by analysis of variance ($p<0.05$). Turkey-19006 ginger powdered sample showed the least moisture content (Mean ± SD value: 60.3±0.32%) when stored in an air tight jar at room temperature in the dark, whereas the most moisture absorption was observed in Thailand-18004 dried ginger powder sample *i.e.* 8.41±0.34% in the same storage conditions.

Findings of moisture content in 98 samples of ginger collected from local farms in the Queensland [20], go in line with the current results 6.85 to 13.72 % (mean ±SD =9.96 ±1.37; n =98). Similar findings for moisture content in ginger powder have also been reported earlier 6.35±0.21 % [21]. Some studies have reported the moisture values for ginger powders which go diverse with the recent results 3.6±0.07 % [10] and 15.2±0.04 % [11].

4.4.2 Ash

The ash content in a food sample measures the total inorganic material found in that food item. Ash content of a food can be responsible for its various nutritional and physicochemical properties. Determination of the ash quantity in any food sample is part of the proximate compositional study essential for nutritional evaluation of the food item. Mean values of ash content of different ginger powder samples in the current study have been recorded to be ranging between 4.43±0.15 and 6.63±0.06 percent on dry basis. Statistics show a significant difference among the various varieties ($p<0.05$). The highest

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

value of mean ash content has been recorded in Turkey-19006, and the lowest in India-17002.

Some of the previous findings on ash content of dried ginger go parallel with the recent study's outcomes whereas other values somehow contradict with the current results. The data found on ash content in the dried ginger reported in early researches, 3.85±0.61 % [11]; 6.42±0.16 % [21] and 5.97±0.04% [22] are similar to the recent findings but ash content in the dried ginger reported by [10] i.e. 3.3±0.04 % is much lower than recently recorded values.

4.4.3 Crude Fat

The term crude fat, also known as ether extract, crude lipid, free lipid content or simply the fat, refers to the total amount of fat present in a food sample including fat-soluble vitamins, mono- di- and tri-glycerides, free fatty acids, carotene pigments, phospholipids and other materials which can be dissolved in fat-dissolving solvents. Crude fat measurement in a food sample is an essential part of the proximate analysis so as to assess the overall nutritional value of the food product.

The recorded mean values of crude fat concentration of different ginger varieties ranged between 4.07% and 7.08% in the recent study. A significant difference among the different varieties was indicated by the statistical analysis ($p<0.05$). The highest amount of crude fat was found in Thailand-18004 (7.08±0.06%) followed by Turkey-19006 (6.78±0.21) with a non-significant difference between each other, whereas significantly lower values of crude fat were seen in India-17002 variety (4.07±0.05%) on dry basis.

Fat content in ginger is varying in different studies. The current findings are found to be close to those reported earlier 3.72±0.03 % [11], 5.23±0.13 % [21]and 5.54±0.02% [22]. Sangwan *et al.* [10] had reported an extremely lower mean value of crude fat in dried ginger i.e. 0.78±0.02 % than the crude fat concentration found in the recent study.

4.4.4 Crude Protein

The term "crude protein" implies to the amount of nitrogenous compounds present in a food sample which mainly comprises the protein molecules composed of amino acids of which nitrogen 'N' is an essential building element. It is determined by chemically analyzing the amount of nitrogen present in the specimen. Estimation of crude protein is crucial for nutritional profiling of the food item as it is the nutrient having a wide structural and functional significance in the living bodies.

The mean values of crude protein measured in different ginger varieties in the current study ranged from 5.80±0.28 % to 9.46±0.26 % with the highest protein content found in Turkey-19006 and the lowest in Thailand-18004. Statistical analysis ($p<0.05$) indicated a non-significant difference among China-AARI23, India-17002 and Turkey-19006, whereas Thailand-18004 demonstrated the lowest protein value of crude protein among all varieties.

Previous studies' data about the protein content of dried ginger are analogous with the least value found in the recent study. Protein content reported in previous studies on the

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

dried ginger, 5.0±0.05 % [10]; 5.08±0.09 % [11] and 5.28±0.43% [22] go in line with the Thailand-18004 showing the lowest of all varieties' protein values in the current study (Fig.2).

4.4.5 Crude Fiber

In the plant foods, there is an essential component composed of the residual material of plants including tough cellulose, hemicelluloses and lignin making up the indigestible part of the food item and is termed as the crude fiber. The crude fiber content in a food sample forms an important fraction and its determination is a crucial part of the proximate analysis in order to estimate the nutritional profile of the food item. It is determined via a series of chemical treatments of the sample and the values are expressed as percentage of the dried food samples.

The crude fiber content represented in the current findings lied in a range of 5.14 to 6.37% with the lowest *i.e.* 5.14±0.06% found in China-AARI23 and the highest *i.e.* 6.37±0.12% present in India-17002 variety. The crude fiber value for China-AARI23 was significantly lower as compared to all other lines, though a non-significant difference existed among Thailand-18004, Turkey-19006 and India-17002.

Varying values of crude fiber content of ginger powder have been reported earlier by different researchers. Crude fiber value was observed to be varying between 4.9 and 5.6 % [10] using different drying methods. A study has reported the insoluble fiber content in ginger to be remarkably greater than the current outcome 23.5±0.06 % [11].

4.4.6 NFE

The residual content of the food sample devoid of moisture, ash, crude fat, crude protein and crude fiber actually represents the water-soluble polysaccharides which include sugars and starches present in that food sample and is termed and Nitrogen-free Extract (NFE). Technically it's not measured through chemical analysis but is found out via subtracting the values of moisture, ash, crude fat, protein and crude fiber from original sample weight and is an essential component of proximate compositional study. A significant difference is found among different ginger varieties' NFE component in the dried samples ($p<0.05$).

Data regarding the recent findings about the NFE content in different varieties of ginger show that mean value of India-17002 was the highest *i.e.* 69.39±0.84% followed by China-AARI23 (67.77±0.85%) but that of Turkey-19006 was found to be the lowest *i.e.* 64.87±0.33%.

Previous studies' data found on the NFE mean values show varying values of soluble polysaccharides in dried ginger samples amongst which findings by [11] i.e. 63.85±1.12 % had been lower than any of the current mean value whereas NFE values 66.26±1.03% [22] and 67.81±1.2 % [16] reported previously were highly correspondent to the recent findings in terms of NFE concentration in ginger on dry basis.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

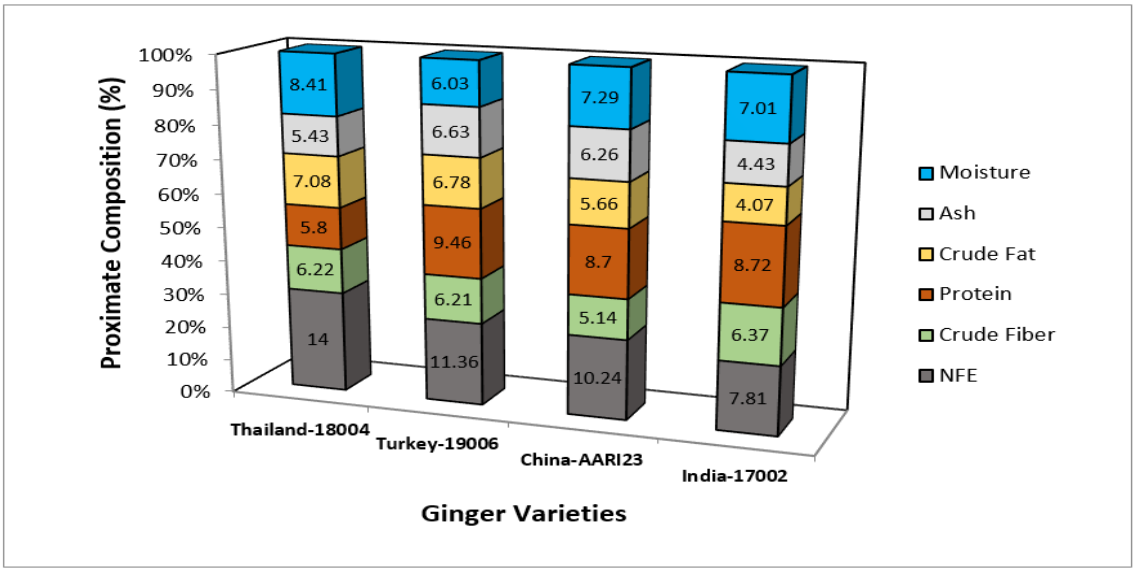

Figure 2: Proximate composition (%) of ginger powder

4.5 Mineral Profile

Different macro and micro minerals' concentrations tested in the ginger varieties through AA-spectrophotometer are given in Table 3. The values of calcium, magnesium, zinc and copper are represented as mean ± SD of 3 replicates in mg/100 g, and those of chromium are given inµg/100 g of dry weight (DW) of ginger. In our findings it is depicted that Turkey-19006 showing the significantly higher amounts, is the richest source of calcium having 271.42±3.22 mg/100 g, followed by China-AARI23 with 253.08±1.63 mg/100 g and Thailand-18004 with 172.67±1.01 mg calcium in 100 g of ginger on dry basis. Least calcium was found in India-17002 (145.42±1.38 mg/100 g) on dry basis.

Table 3: Mineral profile of dried ginger

Ginger Sample	Calcium (mg/100 g)	Magnesium (mg/100 g)	Zinc (mg/100 g)	Copper (mg/100 g)	Chromium (µg/100 g)
Thailand-18004	172.67±1.01^{c}	485.83±0.80^{c}	2.61±0.04^{b}	4.15±0.07^{a}	100±0.00
Turkey-19006	271.42±3.22^{a}	595.92±1.70^{a}	3.62±0.03^{a}	4.19±0.02^{a}	100±0.00
China-AARI23	253.08±1.63^{b}	585.33±0.88^{b}	1.64±0.05^{d}	2.61±0.02^{b}	-
India-17002	145.42±1.38^{d}	412.75±0.66^{d}	2.22±0.03^{c}	0.82±0.02^{c}	-

Values are mentioned as mean±SD; n=3; Values in a column not sharing a letter differ significantly with each other (p<0.05).

The amount of magnesium in Turkey-19006 (595.92±1.70 mg) was found to be considerably greater than all other varieties followed by China-AARI23 (585.33±0.88 mg), and significantly lower values were discovered in, Thailand-18004 (485.83±0.80 mg) and India (412.75±0.66 mg) in 100 g of dry samples. Zinc level of each ginger variety has

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

been identified to be greatly varying among each other ($p<0.05$). Turkey-19006 was found to be the richest whereas China-AARI23 being the poorest source of zinc with concentrations 3.62±0.03 and 1.64±0.05 mg/100 g of dried ginger samples. There was a remarkable difference observed in the copper content of different ginger samples ($p<0.05$). The highest amounts of copper were recorded in Turkey-19006 and Thailand-18004 (4.19±0.02 and 4.15±0.07 mg/100 g, respectively) with no significant diiference between the both varieties, whereas significantly low values were found in China-AARI23 (2.61±0.02 mg) and India-17002 (0.82±0.02 mg) in 100 g ginger on dry basis. Traces of chromium (100±0.00 µg/100 g) were found to be present in Thailand-18004 and Turkey-19006 while very negligible amounts could be detected in China-AARI23 and India-17002 ginger varieties.

4.6 Functional Group Profile

The Frontier Transmittance Infrared (FTIR) spectroscopy was used to identify the functional groups present in ginger powder obtained from different varieties. The FTIR spectra of various ginger varieties' ball-milled powder are displayed in Fig.3. At room temperature, the FTIR spectra are obtained from wave number 400 cm^{-1} to 4000 cm^{-1}. Tables 4 shows the specifics of the functional groups found in the material of prepared samples. FTIR spectra were interpreted to have an idea of types of molecules present in the biological materials with the help of determination of chemical bonding from the spectral representation. The spectrum of each variety generally displayed a broad band between 3000 and 3500 cm^{-1}, as depicted in Fig. 3.

Table 4: FTIR spectroscopic analysis of ginger powder

Wavelength range (cm^{-1})	Type of vibration	Functional group	Characteristic absorption (cm^{-1})			
			Thailand-18004	Turkey-19006	China-AARI23	India-17002
3300 – 3500	Stretch	O-H alcohol	3297.5	3272.8	3272.6	3283.8
2850 – 3000	Stretch	C-H alkane	2920.4	2922.2	2922.2	2928.0
2100 – 2500	Stretch	C=C Conjugated	-	2193.8; 2329.6; 2357.5	-	2005.3; 2193.5; 2329.6
1600 – 1650	Stretch	C=C benzene ring	1636.3	-	1634.4	1634.4
1500 – 1550	Stretch	Polyphenol skeletal stretch	1515.2	-	1515.2	1518.9; 1558.0
1350 – 1470	Stretch	C-H alkane	1326.9; 1389.8; 1394.0	-	1373.5	1321.3; 1373.5; 1418.3; 1455.5
950 – 1300	Bending	C-O alcohol	1149.9	1148.0; 1293.3	1148.0; 1239.3	1149.9; 1239.3
990 – 1000	Bending	C=C Terpenes like zingiberene	997.1	993.3	993.3	993.3
650 – 900	Bending	C=C alkene	-	861.0; 762.2; 669.1	861.0; 762.2	-
~1075	Bending	C-H sugars	1077.2	1075.3	1076.3	1075.3

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

The spectra of four varieties were more or less similar to each other except some strong overtones in Thailand-18004 between absorption region 1750 – 2250 cm^{-1} indication more number of benzene ring structures pointing towards possibly higher concentration of phenolic compounds in the variety [23]. The spectra are generally displaying a broad, somehow weak stretch between 3300 and 3500 cm^{-1}. This band possibly have resulted from hydrogen bonds and stretching of the O–H bond, like in alcohols. It is possible to attribute the peak between 2850 and 3000 cm^{-1} to sp3 C–H stretching giving a clue to hydrocarbon alkane chain. The C=C stretching of benzene rings of phenolic compounds may be the cause of the peaks at wavelengths between 2100 and 2500 cm^{-1}. The CO bond-related peaks of alcohols and sugars were detected in the range of 950 to 1300 cm^{-1}. The identification of aromatic polyphenolic skeletal stretch forming spectral peaks from 1500 to 1550 cm^{-1} and between 1600 to 1650 cm^{-1} might be used to explain the presence of phenolic compounds. The C–H stretching of alkane was identified as the peaks between 1350–1470 cm^{-1}. The C=C bending at 990 – 1000 cm-1 may characterize the C=C bonding of terpenes like zingiberene [23].

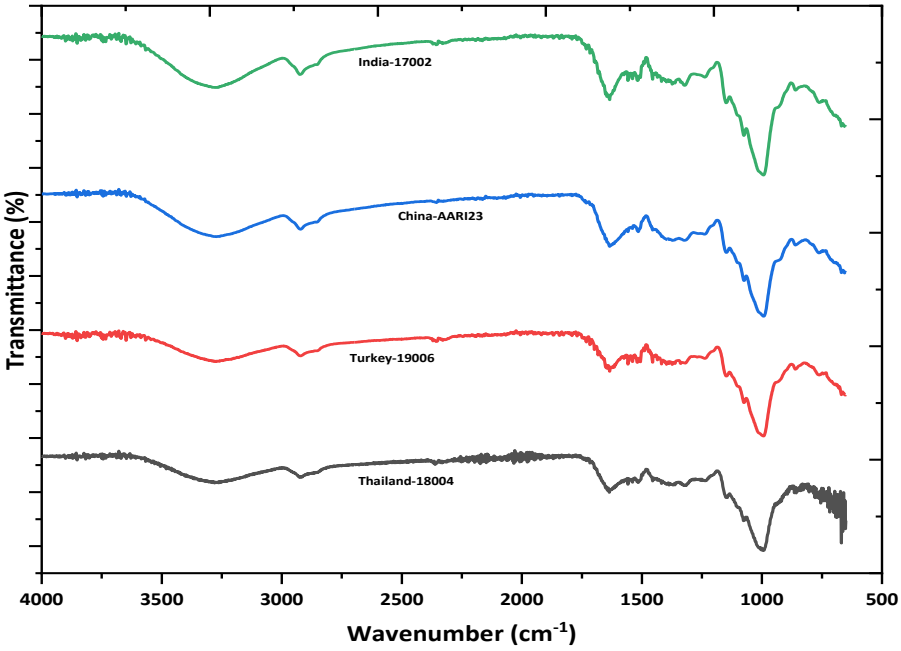

Figure 3: FTIR spectrum of ginger powder

4.7 Colour Detection

The colour attributes of any food item can be a useful indicator of its antioxidant properties. Colour values L*, a* and b* of different dried ginger samples are represented in Table 4. The L* value indicates the lightness of the sample ranging from dark to light (Dark < 50 < Light) on a scale of 0-100, whereas a* and b* are chromaticity values ranging

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

from green to red, and blue to yellow, respectively. Negative a* values correspond to green saturation, positive to red; negative b* values indicate more blue saturation while positive represents more yellow [24].

Table 5 demostrates various colour parameters of dried ginger samples. Lightness of different ginger varieties ranged between 25.47 and 58.51 with Thailand-18004 being the lightest of all (L*: 58.51±0.37) and India-17002, China-AARI23 and Turkey-19006 having L* values less than 50. All the varieties show positive values of a* and b* indicating more red and yellow saturations, respectively. It was observed that Thailand-18004 tended to show the highest red as well as yellow saturation of all varieties (a*: 7.21±0.12; b*: 23.27±0.16) whereas Turkey-19006 showed the least tendency towards redness and yellowness. The colour characteristics of different varieties gave them their particular appearance as bright yellow to Thailand-18004 and comparatively dull yellow appearance to China-AARI23, India-17002 and Turkey-19006 varieties.

Table 5: Colour range of dried ginger

Ginger Sample	Lightness (L*)	Red-green scale (a*)	Yellow-blue scale (b*)
Thailand-18004	58.51 ± 0.37^{a}	7.21 ± 0.12^{a}	23.27 ± 0.16^{a}
Turkey-19006	25.47 ± 0.37^{d}	5.06 ± 0.03^{d}	15.21 ± 0.13^{c}
China-AARI23	34.65 ± 0.32^{c}	6.68 ± 0.20^{b}	15.84 ± 0.32^{b}
India-17002	40.48 ± 0.29^{b}	6.09 ± 0.03^{c}	15.98 ± 0.09^{b}

Values are mentioned as mean±SD; n=3; Values in a column not sharing a letter differ significantly with each other ($p<0.05$).

5. CONCLUSION

Ginger seeds collected from different origins grown in Pakistan, are compareable to ginger grown in various parts of the world in terms of their nutritional profile. Among the four tested lines/varieties of ginger, Thailand-18004 has been found to be the best regarding to its proximate composition, mineral, functional and bioactive profile. More ginger lines/varieties being tested/grown in Pakistan should be taken into account for future research. The nutritional and functional profiling should be extended by considering estimation of further minerals and bioactive compounds.

Acknowledgment

Madiha Javid would like to express her gratitude to her supervisor, Dr. Rizwan Shukat, Assistant Professor NIFSAT, University of Agriculture Faisalabad, Pakistan for his thorough analysis and rigorous critique improved the quality of this project. She expresses thanks to the members of her research supervisory committee for continued support and encouragement as well as for their valuable and expert guidance in the completion of her research work: Dr. Mian Kamran Sharif and Dr. Muhammad Naeem Faisal. Our sincere gratitude also goes to Dr. Amir Latif, Senior Scientist AARI Faisalabad, Pakistan, for helping out in the procurement of the raw material that was a dire need of the project.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

Abbreviations

AARI	Ayub Agricultural Research Institute
ANOVA	Analysis of Variance
FTIR	Fourior Transform Infrared Spectroscopy
NIFSAT	National Institute of Food Science and Technology
NFE	Nitrogen Free Extract (NFE)

References

1) V. Majithia, C.R. Sona and C. Ahmedabad, “Effects of Extracts of Traditional Indian Spices, Garlic (*Allium sativum*) and Ginger (*Zingiber officinale*) on the Growth Rate of *Escherichia coli* (*E. coli*) and Bacillus subtilis (*B. subtilis*),” *Int. J. Sci. Acad. Res.*, vol. 3, no. 211, pp. 3-7, 2018.

2) S.J. Sunday, “Comparative Nutritional Value Analysis of Oven Dried and Sun Dried Ginger (*Zingiber officinale*) and their Tenderization Effects on Old Layer Chickens in Pankshin Lga of Plateau State, Nigeria,” *J. Exp. Food Chem.*, vol. 6, no. 3, pp. 1-5, 2020.

3) Z. Yang, G. Zhenghao, Y. Jun and X. Jing, “Nutritional Components, Phytochemical Compositions, Biological Properties, and Potential Food Applications of Ginger (*Zingiber officinale*): A Comprehensive Review,” *J. Food Compos. Anal.*, vol. 128, e106057, 2024.

4) D. Jabborova, R. Choudhary, A. Azimov, Z. Jabbarov, S. Selim, M. Abu-Elghait, S.E. Desouky, I.H. El Azab, A.M. Alsuhaibani, A. Khattab and A. ElSaied, “Composition of *Zingiber officinale* Roscoe (Ginger), Soil Properties and Soil Enzyme Activities Grown in Different Concentration of Mineral Fertilizers,” *Horticulture*, vol. 8, no. 43, 2022.

5) R. Andriyani, T.A. Budiati and S. Pudjiraharti, “Effect of Extraction Method on Total Flavonoid, Total Phenolic Content, Antioxidant and Antibacterial Activity of *Zingiberis officinale* Rhizome,” *Procedia Chem.*, vol. 16, pp. 149-154, 2015.

6) J. Zagórska, W. Kukula-Koch, M. Czop, K. Iłowiecka and W. Koch, “Impact of Thermal Processing on the Composition of *Curcuma longa* Rhizome,” *Foods*, vol. 12, no. 16, p. 3086, 2023.

7) D.K. Poudel, S. Dangol, A. Rokaya, S. Maharjan, P.K. Ojha, J. Rana and W.N. Setzer, “Quality Assessment of *Zingiber officinale* Roscoe Essential Oil from Nepal,” *Nat. Prod. Commun.*, vol. 17, no. 3, pp. 1-10, 2022.

8) R. Jan, A. Gani, M. M. Dar and N. A. Bhat, “Bioactive Characterization of Ultrasonicated Ginger (*Zingiber officinale*) and Licorice (*Glycyrrhiza glabra*) Freeze Dried Extracts,” *Ultrason. Sonochem.,* vol. 88, e106048, 2022.

9) O.N. Richard and O.B. Paul, “Ginger: Its Essentials and Chemico–Ali Nature to the Benefit of Mankind,” *IJIRMF*, vol. 2, no. 12, pp. 322-327, 2016.

10) A. Sangwan, A. Kawatra and S. Sehgal, “Nutritional Composition of Ginger Powder Prepared Using Various Drying Methods,” *J. Food Sci. Technol.*, vol. 51, no. 9, pp. 2260-2262, 2014.

11) A.P.R. Shirin and J. Prakash, “Chemical Composition and Antioxidant Properties of Ginger Root (*Zingiber officinale*),” *J. Med. Plants Research*., vol. 4, no. 24, pp. 2674-2679, 2011.

12) M. Shahid and F. Hussain, “Chemical Composition and Mineral Contents of *Zingiber officinale* and *Alpinia allughas* (Zingiberaceae) Rhizomes,” *IJCBS*, vol. 2, pp. 101-104. 2012.

Tianjin Daxue Xuebao (Ziran Kexue yu Gongcheng Jishu Ban)/
Journal of Tianjin University Science and Technology
ISSN (Online):0493-2137
E-Publication: Online Open Access
Vol: 57 Issue: 12:2024
DOI:10.5281/zenodo.14293462

13) A.A.H. Ali, “Overview of the Vital Roles of Macro Minerals in the Human Body,” *J. Trace Elem. Min.*, vol. 4, e100076, 2023.

14) S.I. Soomroa, N. Memona, M.I. Bhangerb, S. Memona and A.A. Memona, “Mineral Content of Pakistani Foods: An Update of Food Composition Database of Pakistan Through Indirect Method,” *J. Food Compos. Anal.*, vol. 51, pp. 45-54, 2016.

15) A. Rachkeeree, K. Kantadoung, R. Suksathan, R. Puangpradab, P.A. Page and S.R. Sommano, “Nutritional Compositions and Phytochemical Properties of the Edible Flowers from Selected Zingiberaceae Found in Thailand,” *Front. Nutr.*, vol. 5, no. 3, pp. 1-10, 2018.

16) B. Kefale, M.A. Delele, S.W. Fanta S.M. Abate, “Nutritional, Physicochemical, Functional, and Textural Properties of Red Pepper (*Capsicum annuum* l.), Red Onion (*Allium cepa*), Ginger (*Zingiber officinale*), and Garlic (*Allium sativum*): Main Ingredients for the Preparation of Spicy Foods in Ethiopia,” *J. Food Qual.*, vol. 2023, no. 15, pp. 1-13, 2023.

17) X. Hou, S. Lv, Z. Chen and F. Xiao, “Applications of Fourier Transform Infrared Spectroscopy Technologies on Asphalt Materials,” *Meas. J. Int. Meas. Confed.*, vol. 121, pp. 304-316, 2018.

18) AOAC. *Official Methods of Analysis of AOAC International*, 22nd Ed., Oxford University Press, New York, USA, 2023.

19) S. Varakumar, K.V. Umesh, R.S. Singhal, “Enhanced Extraction of Oleoresin from Ginger (*Zingiber officinale*) Rhizome Powder Using Enzyme-Assisted Three Phase Partitioning,” *Food Chem.*, vol. 1, no. 216, pp. 27-36, 2017.

20) J.B. Johnson, J.S. Mani a, S. White, P. Brown and M. Naiker, Quantitative Profiling of Gingerol and its Derivatives in Australian Ginger,” *J. Food Compos. Anal.*, vol. 104, e104190, 2021.

21) M. Javid, Bioevaluation of Nutri-Therapeutic Potential of Ginger Extract against Hyperglycemia and Dyslipidemia in Type II Diabetes Mellitus,” GCWUF. 2019.

22) I.G. Adanlawo and F.A.S. Dairo, “Nutrient and Antinutrient Constituents of Ginger (*Zingiber officinale*, Roscoe) and the Influence of its Ethanolic Extract on Some Serum Enzymes in Albino Rats,” *Int. J. Biol. Chem.*, vol. 1, pp. 38-46, 2007.

23) I.K. Amponsah, A. Boakye, E. Orman, F.A. Armah, L.S. Borquaye, S. Adjei, Y.A. Dwamena, K.A. Baah and B.K. Harley, “Assessment of Some Quality Parameters and Chemometric-Assisted FTIR Spectral Analysis of Commercial Powdered Ginger Products on the Ghanaian Market,” *Heliyon*, vol. 8, e09150. 2022.

24) A.L. Jayathilake, M.A. Jayasinghe and J. Walpita, Development of Ginger, Turmeric Oleoresins and Pomegranate Peel Extracts Incorporated Pasteurized Milk with Pharmacologically Important Active Compounds,” *Appl. Food Res.*, vol. 2, e100063. 2022.