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PHYSICAL AND CHEMICAL PROPERTIES OF GINGER CULTIVARS PROCURED FROM DIFFERENT LOCATIONS IN NIGERIA

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ABSTRACT

Physical and chemical properties of ginger cultivars procured from different locations in Nigeria were evaluated. The average rhizome length, breadth, thickness, weight, volume and density varied from 9.3 to 14.2cm, 3.2 to 6.6cm, 0.7 to 2.1cm, and 61.62 to 195.03g, 63.12 to 196.99cc and 0.86 to 0.89g/cc, respectively. The biochemical properties of ginger cultivars (dried ginger powder) which include moisture, ash, carbohydrate, protein, ascorbic acid, crude fibre, essential oil, oleoresin, calcium, phosphorus, iron, zinc and copper content procured from different locations in Nigeria varied from 7.36 to 8.09%, 5.83 to 6.76%, 55.39 to 63.79%, 5.70 to 10.37%, 0.06 to 0.17mg/100ml, 5.23 to 6.50%, 1.44 to 2.40%, 4.55 to 6.40%, 0.54 to 0.85%, 0.43 to 0.86%, 0.20 to 0.32%, 0.13 to 0.35%, and 1.03 to 2.14%, respectively. The essential oil content in fresh ginger varied from 0.23 to 0.32%. The oil content in ginger (dried ginger powder) cultivars was analyzed for aroma characteristics and the expert panel of 10 members identified the oil samples as pungent, spicy, earthy, harsh, camphoraceous, warm and lemony. The colour of oil extracted after steam distillation of ginger cultivars varied from pale yellow to golden yellow, while some samples had a sparkling light yellow colour. Ginger cultivars grown in different states of the federation are very nutritious and have great potential for processing and value addition.

KEYWORDS: Physical, Chemical, Properties, Ginger, Nigeria.

INTRODUCTION

Due to favourable climatic and soil conditions present in Nigeria, varieties of species of spices are cultivated in the country. The data bank shows that every year, quite a large quantity of spices is exported to many developed and underdeveloped countries of the world from Nigeria. About five Nigerian spices have fetched the ready overseas export market. Among the various categories of spices in Nigeria, ginger is one of the four most important spices produced in the country (NRCRI, 2005).

Ginger (*Zingiber officinale* R) is a tropical tuber crop and belongs to the order Zingiberales and family Zingiberaceae. It is the rhizome of a perennial and monocotyledonous herbaceous plant. It is native of South Eastern Asia and is cultivated in India, Africa, Jamaica, Indonesia, Australia, China and Japan. Nigeria is among the major producers and exporters of ginger in the world. The cultivation of ginger started in Nigeria in 1927 and the locations include Southern Zaria, Jemma federated districts and neigbouring parts of Plateau (Okwuowulu, 1997). NRCRI (2005) confirmed that ginger grows well in the rainforest region of the country where rainfall is above 2000mm and altitudes ranging from 0-800meters above sea level within a temperature range of 25^0C – 35^0C. The reality on ground is that today ginger can grow not only in Kaduna State, but also in other parts of Nigeria such as Gombe, Bauchi, Benue, Nasarawa, Niger, Sokoto, Osun, Anambra, Zamfara, Akwa-Ibom, Oyo, Abia, Lagos, Imo, Cross River, Ebonyi and Abuja (NRCRI, 2005).

The nutritional composition of ginger shows that it contains an appreciable amount of minerals, fiber, carbohydrates and ample amount of vitamins A and C (ascorbic acid), and when taken as vegetable, it supplies reasonable quantity of protein in human diet (Chuma, 2004). Ginger is known for its ability to warm people. In his Theatrum Botanicum of 1640, the herbalist John Parkinson wrote, “the properties of ginger are to warm a cold stomach and to help digestion” (Ghorse, 2005). Ginger is stimulant and carminative that aids digestion and reduces flatulence. Ginger is used as an ingredient in various spice blends, in food processing and beverage industries. It is a frequent constituent of curry powder and widely used for manufacturing of ginger bread, biscuits, cakes, soups and for soft drink like ginger-ale and carbonated drinks, etc. (Okafor, 2002). It is also in great demand for traditional food preparations and medicinal uses (WHO 2008; My health 2009).

The present scenario indicates that there is great demand of ginger and ginger based products in Nigeria and abroad. Evaluation of ginger varieties present in the country for the

identification of quality traits like high volatile oil content, high oleoresin content and low fibre content are important aspect for value addition to be studied in detail. The information about the quality of ginger cultivars in Nigeria are quite meager. Therefore, the present investigation was aimed at evaluating the physical and chemical properties of ginger cultivars procured from different locations in Nigeria.

MATERIALS AND METHODS

Procurement of Fresh Ginger Samples

The samples of fresh ginger were procured from seven states of Nigeria where they were cultivated namely Plateau, Gombe, Bauchi, Benue, Nasarawa, Niger and Kaduna, and were designated as G_1, G_2, G_3, G_4, G_5, G_6 and G_7 respectively. They were separately packed in polythene bags and stored at 4^0C in refrigerator. For further use in analysis and processing, the ginger samples were separately washed in running tap water to remove adhering dust, dirt and mud.

Physical Attributes Determination Methods

The appearance and size of the washed fresh gingers procured from the seven states were determined by visual observations. The length and thickness of each ginger was recorded in centimeter using Vernier Caliper. Randomly, 10 ginger rhizomes of each state were weighed accurately and the average weight was calculated. In the similar way, volume of each rhizome in cubic centimeter was determined using water displacement method. The density of the rhizome in gram per cubic centimeter was determined by dividing the weight of the rhizome by its volume.

Sample Preparation for Chemical Attributes Determination

The separately washed fresh ginger samples were peeled and then sliced. The sliced ginger was dried at 65^0C in a hot air oven, and the evaporation rate was observed in an alternate hour. The dried sliced ginger was ground by laboratory grinder and stored in airtight polythene bags for further studies.

Chemical Attributes of Dried Ginger Powder

Proximate Composition

The moisture, protein, carbohydrate, total ash, crude fibre and ascorbic acid contents in dried ginger powder were determined by methods as given in AOAC (1980).

Mineral Nutrients

Mineral nutrients namely, phosphorus, zinc, copper, iron and calcium were determined in diacid-digested aliquot using the following methods as given below: 1 gram of powdered sample was placed in 100ml conical flask and 15ml of diacid mixture consisting of nitric acid (HNO_3) and perchloric acid ($HCIO_4$) in proportion of 5:2 was added. The mixture was kept heated on a hot plate and digested until a clear aliquot was obtained. The digested material was filtered through Whatman No. 1 filter paper and its volume was made up to 100ml. The aliquot was used for the determination of the above minerals. The phosphorus content was determined by Vanado-molybelate phosphoric acid method of Koenig and Johnson (1942). Zinc, copper and iron in diacid digested aliquot were determined by using Atomic Absorption spectrophotometer. Calcium content in diacid digest was determined by the Versenate titration method as described by Black (1965).

Estimation of Ginger Oil by Distillation Method

The ginger oil was estimated using Clevenger apparatus. The oil was extracted from both fresh ginger and dried ginger powder. 300g fresh ginger and 100g dried ginger powder were used for extraction of essential oil. Fresh ginger was cut into 3 to 5mm slices and then directly put it into the Clevenger apparatus. The process involves heating water to produce steam, which carries most of the volatile component with it. The steam was chilled in a condenser and the distillate resulting was collected from the side arm of Clevenger. The essential oil floats on the top of the hydro salt and was separated off. The distillation was continued for 3 hours at 100^0C.

Estimation Of Oleoresin In Ginger Powder

Oleoresin content in ginger powder was determined by Soxhlet extraction method as given in AOAC (1970) using petroleum ether.

Sensory analysis of ginger oil

Trained panel expert of 10 members were given ginger oil samples to evaluate the sensory attributes on the basis of colour and odour characteristics. The hedonic rating test was adopted by following the procedure of Ranganna (1991)

Statistical Analysis

Following the method as described by Panse and Sukhatme (1957), the data obtained from the experiment were statistically analysed. The standard error of mean (SEm±) and Critical

Difference (CD at 5%) values are presented at the bottom of table. Analysis of variance was used to check for significant difference between cultivars.

RESULTS

The results of the physical properties of fresh ginger procured from different states of the country is shown in (Table 1).

Table 1: Physical properties of fresh ginger procured from different location of Nigeria

S/N	Code	Length of Rhizome (cm)	Breadth (cm)	Thickness of Rhizome (cm)	Wt. of Rhizome (g)	Volume (cc)	Density (g/cc)	Size	Appearance
1	G_1	13.1	6.6	1.7	168.11	169.00	0.89	Large	Light brown to yellowish; bold and unpeeled skin
2	G_2	9.4	3.7	1.2	61.62	63.12	0.87	Small	Yellowish brown; and roughly peeled skin
3	G_3	10.8	4.7	1.1	71.16	73.20	0.87	Medium	Pale brown; unpeeled, wrinkled and corky skin
4	G_4	9.6	3.9	1.0	68.75	70.23	0.87	Small	Camel brown; smooth, bold and uniform skin
5	G_5	11.4	5.5	0.5	91.94	93.32	0.88	Medium	Grayish brown; and partly scrapped skin
6	G_6	9.3	3.2	0.7	82.48	85.12	0.86	Small	Light buff; wrinkled and corky skin
7	G_7	14.2	6.5	2.1	195.03	196.99	0.89	Large	Pale brown; bold and unpeeled skin.

The values are average of three replications

The rhizome length, breadth, thickness and weight varied from 9.3 to 14.2cm, 3.2 to 6.6cm, 0.7 to 2.1cm and 61.62 to 195.03g, respectively. The maximum length, thickness and weight were recorded in G_7. The volume and density under investigation varied from 63.12 to 196.99cc and 0.86 to 0.89g/cc, respectively. The size of the sample varied from large (G_1 and G_7), medium (G_3 and G_5) and small (G_2, G_4 and G_6).

The proximate composition of the dried ginger powder is given in (Table 2).

Table 2: Proximate composition of dried ginger powder procured from different states of Nigeria

S/N	Code	Moisture (%)	Ash (%)	Carbohydrate (%)	Protein (%)	Ascorbic acid mg/100ml	Crude fibre (%)
1	G_1	7.70	6.13	63.79	8.04	0.06	5.53
2	G_2	7.43	6.03	62.64	8.91	0.09	6.43
3	G_3	7.36	6.76	58.00	5.70	0.11	6.50
4	G_4	7.56	5.83	59.81	10.37	0.14	6.13
5	G_5	7.83	6.06	62.41	6.06	0.10	5.73
6	G_6	7.56	5.86	57.61	10.08	0.09	5.53
7	G_7	8.09	6.36	55.39	5.71	0.17	5.23
	SEm±	0.06	0.07	0.21	0.24	0.004	0.07
	CD at 5%	0.20	0.24	0.63	0.75	0.01	0.21

The moisture content ranged from 7.36 to 8.09% in the various samples of the dried ginger powder. The highest moisture content was observed in G_7 (8.09%) followed by G_5 (7.83%), G_1(7.70%), G_4 and G_6(7.56%), G_2(7.43%) and G_3(7.36%). The G_3, G_2, G_6 and G_4 cultivars were found to be statistically at par with each other. The G_6, G_4 and G_1 were statistically at par with each other. Likewise, G_5 was at par with G_1 and G_7 and G_5 were statistically at per with each other. The variety G_7, G_5 and G_1 were significantly superior over G_3 variety.

From the data presented in (Table 2), it is evident that maximum ash content was found to be 6.76% in G_3 and minimum 5.83% was recorded in G_4 cultivar. The G_4, G_6, G_5 and G_2 were statistically at par with each other. The ginger varieties of states G_5, G_2 and G_1 were also statistically at par with each other. The G_7 having 6.36% as ash content was at par with G_1 having 6.13% ash content. The G_3 was significantly superior over G_7 cultivar.

The carbohydrate content in the ginger powder also presented in (Table 2) shows a variation from 63.79% in G_1 to 55.39% in G_7 followed by G_2 (62.64%), G_5 (62.41%), G_4(59.81%), G_3(58.00%) and G_6(57.61%). The carbohydrate content of G_3 and G_6 were found to be statistically at par with each other. Similarly, G_5 and G_2 were also statistically at par with each other. G_6 was significantly superior over G_7. G_5 having 62.41% carbohydrate content was significantly superior over G_4 having 59.81% carbohydrate content. There was also a significant different between G_1 and G_2.

The results of protein content indicates that maximum protein was found to be 10.37% in G_4 and minimum 5.70% was present in G_3. The cultivars namely G_3, G_7 and G_5 were statistically at par with each other. Likewise, G_4 having 10.37% protein content was found to be at par with G_6 having 10.08% protein content. The G_1 was significantly superior over G_5. Similarly, the G_2 was significantly superior over G_1. Also, there was a significant difference between G_6 and G_2.

An appraisal of (Table 2) exhibited a range of 0.17mg/100ml to 0.06mg/100ml of ascorbic acid present in ginger powder obtained from different states. This was maximum in G_7 with 0.17mg/100ml and minimum in G_1 with 0.06mg/100ml. The G_2 was at par with G_6, the later was also at par with G_5. Similarly, the G_5 was at par with G_3 cultivar. The G_2 was significantly superior over G_1. The G_4 having 0.14mg/100ml ascorbic acid was significantly superior over G_3 having 0.11mg/100ml ascorbic acid. Also, the was a significant difference between G_7 and G_4 cultivars.

Table 2 also shows that ginger powder procured from different states contained fibre ranging from a maximum 6.50% in G_3 and minimum 5.23% in G_7, followed by G_2, G_4, G_5, G_1 and G_6 having 6.43, 6.13, 5.73 and 5.53% respectively. The crude fibre content of G_5, G_1 and G_6 were found to be statistically at par with each other. G_3 was at par with G_2. The G_6 was significantly superior over G_7. Also, there was a significant difference between G_2 and G_4 cultivars.

The results of mineral nutrient composition of ginger procured from seven states are presented in (Table 3).

Table 3: Mineral nutrients' composition of ginger cultivars from the seven states

S/N	Code	Calcium (%)	Phosphorus (%)	Iron (%)	Zinc (%)	Copper (%)
1	G_1	0.76	0.86	0.32	0.35	1.03
2	G_2	0.67	0.65	0.25	0.13	1.17
3	G_3	0.75	0.58	0.20	0.15	2.14
4	G_4	0.64	0.78	0.20	0.26	2.01
5	G_5	0.85	0.63	0.22	0.26	1.24
6	G_6	0.54	0.54	0.25	0.16	1.95
7	G_7	0.76	0.43	0.22	0.20	1.29
	SEm±	0.01	0.008	0.06	0.003	0.09
	CD at 5%	0.03	0.02	0.18	0.01	0.27

The ginger powder prepared from seven states contained calcium content ranging from maximum 0.85% in G_5 and minimum 0.54% in G_6 cultivar, followed by G_7, G_1, G_3, G_2 and G_4 having 0.76, 0.76, 0.75, 0.67 and 0.64%, respectively. The calcium content of G_2 and G_4 were statistically found to be at par with each other. The G_1, G_3 and G_7 were also statistically at par with each other. There was a significant difference between G_5 and G_7 cultivars.

The maximum phosphorus content was found to be 0.86% in G_1 and minimum 0.43% in G_7 variety as shown in (Table 3). The G_2 variety having 0.65% phosphorus content was at par with G_5 having 0.63% phosphorus content. The G_6 was significantly superior over G_7. G_3 having 0.58% phosphorus content was significantly superior over G_6 having 0.54% phosphorus content. There was a significant difference between the varieties namely G_5 and G_3. G_4 was also significantly superior over G_2. G_1 having 0.86% phosphorus content was significantly superior over G_4 having 0.78% phosphorus content.

The range of iron content present in dried ginger powder procured from different states is shown in (Table 3). The maximum iron content was found in G_1 with 0.32% and minimum in

G_3 and G_4 with 0.20%. The iron content of ginger cultivars namely, G_4, G_3,G_7,G_5,G_6,G_1 and G_2 were statistically at par with each other. The result differed non-significantly.

Table 3 exhibited a range of 0.35% to 0.13% of zinc content present in ginger powder obtained from different states. This was maximum in G_1 (0.35%) and minimum in G_2 (0.13%). G_6 was at par with G_3, and G_5 was at par with G_4. The G_3 having 0.15% zinc content was significantly superior over G_2 having 0.13% zinc content. There was a significant difference between G_7 and G_6 cultivars. The G_1 was also significantly superior over G_5.

Copper content varied from 2.14% to 1.03% in various dried ginger powder as shown in (Table 3). G_3 was found to have the highest copper content of 2.14% followed by 2.01, 1.95, 1.29, 1.24, 1.17 and 1.03 in G_4, G_6, G_7, G_5, G_2 and G_1, respectively. Data shows that G_7, G_5,G_2 and G_1 were statistically at par with each other. G_3, G_4 and G_6 were also statistically at par with each other. The G_6 having 1.95% copper content is significantly superior over G_7 with 1.29% copper content.

Ginger oil was extracted from both fresh ginger samples as well as in dried ginger powder procured from different states in Nigeria and the percentage of oil is presented in (Table 4).

Table 4: Essential oil content from fresh ginger and dried ginger powder, and oleoresin content from dried ginger powder

		Oil yield (%)		
S/No	**Code**	**Fresh ginger**	**Dried ginger**	**Oleoresin ether extract (%)**
1	G_1	0.32	2.40	6.40
2	G_2	0.29	1.83	5.69
3	G_3	0.23	1.46	4.65
4	G_4	0.26	1.63	5.12
5	G_5	0.30	2.35	6.32
6	G_6	0.23	1.44	4.55
7	G_7	0.29	1.81	5.62
	SEm±	0.005	0.01	0.06
	CD at 5%	0.01	0.03	0.20

From fresh ginger samples, the maximum oil content of 0.32% was found in G_1 and minimum oil content of 0.23% was present in G_3 and G_6. The percentage of oil in G_6 and G_3 were at par with each other. Similarly, G_5 was statistically at par with G_2 and G_7 cultivars. The G_4 cultivar was significantly superior over G_6. There was also a significant difference between G_1 and G_5 cultivars.

In dried ginger powder, the maximum oil content was found in G_1(2.40%) and minimum in G_6(1.44%). The oil contents of G_3 and G_6 were found to be statistically at par with each other. The ginger cultivar G_2 having 1.83% oil was at par with G_7 having 1.81%. The G_4 was significantly superior over G_3. G_5 with 2.35% ginger oil content was significantly superior over G_2 with 1.83% ginger oil content. There was also a significant difference between G_1 and G_5 cultivars.

Estimation of oleoresin content in dried ginger powder is also presented in Table 4. It varied from 6.40% in G_1 to 4.55% in G_6 followed by G_5 (6.32%), G_2(5.69%), G_7(5.62%), G_4(5.12%) and G_3 (4.65%). Oleoresin content of dried ginger powder of cultivars G_3 and G_6, G_2 and G_7, G_1 and G_5 were at par with each other. The statistical analysis of data shows that G_4 with 5.12% oleoresin content was significantly superior over G_3 with 4.65% oleoresin content. G_5 was significantly superior over G_2. There was also a significant difference between G_7 and G_4. Sensory evaluation of ginger oil from dried ginger (powder) procured from different states which varied from 1.44 to 2.40% is presented in (Table 5).

Table 5: Essential oil (%), colour and aroma characteristics of dried ginger powder from different states

S/No	Code	Oil (%)	Colour	Aroma characteristics
1	G_1	2.40	Very pale yellow oil, sparkling	Fairly Lemony, spicy: fairly pungent
2	G_2	1.83	Light cream colour oil	Lemony, aromatic rooty: Pungent
3	G_3	1.46	Very light yellow oil	Lemony, delicately aromatic spicy: strongly pungent
4	G_4	1.63	Golden yellow colour oil	Sweet aromatic rooty: Pungent
5	G_5	2.35	Light yellow colour oil	Mild, strongly lemony, aromatic rooty: Fairly pungent
6	G_6	1.44	Pale yellow volatile light yellow oil	Earthy, camphoraceous: Most pungent
7	G_7	1.81	Light golden yellow colour oil	Delicately aromatic spicy: Mildly pungent

The oil from G_1 was found to be sparkling and very pale yellow in colour. The colour of the oil extracted from G_2 was described as light cream in colour while those from G_3 and G_5 were described to be very light yellow in colour by the sensory panel expert. The oil from G_4 was golden yellow in colour whereas oil from G_7 was light golden yellow in colour. The oil of G_6 was found to be volatile pale yellow in colour.

Varying odour characteristics existed among the extracted ginger oil. Ginger oil from cultivars G_1, G_2, and G_3 had lemony, fairly, gingery, delicate, pleasant gingery flavor while

that from variety G_5 and G_7 had pungent spicy odour. G_4 and G_6 had a sweet, lemony, gingery flavor.

DISCUSSION

The physical properties and bio-chemical composition of ginger are important parameters in determining its botany, appearance and its acceptability for further use in processing. The physical characteristics of ginger differ from cultivar to cultivar. Ginger cultivar obtained from Kaduna State was considered to be of superior quality when compared to the ginger procured from different states in Nigeria. It was large in size, with the maximum length and breadth. The appearance of the ginger collected from Kaduna State was quite attractive and appealing. Also, the physical properties of G_7 cultivar were superior for attributes like thickness, weight, density and volume. The variation in the physical properties of ginger cultivar collected from different states in Nigeria might be due to differences in varieties, as well as in the climatic and soil conditions of the different regions.

Biochemical composition of ginger powder from the seven states was also studied. Among all the seven samples of ginger powder, the G_1 sample was ranked highest in terms of most of the major biochemical properties, such as oleoresin, ginger oil, carbohydrate, and mineral contents like iron, zinc, phosphorus, while G_3 and G_7 cultivars possessed maximum ash, crude fibre, copper, moisture and ascorbic acid content. Where as G_4 sample contain maximum protein content, G_5 sample possessed maximum calcium content. Additionally while minor differences existed among the values of ascorbic acid, iron, calcium, phosphorus and zinc contents, a significant difference was observed among G_1, G_2, G_3, G_4, G_6 and G_7 samples with respect to that of moisture, ash, carbohydrate, protein, crude fibre, ginger oil, oleoresin and copper contents. These differences might be attributed to variation in locations, development time and maturity of the ginger rhizomes. In addition, the biochemical composition variations might also be attributed to the rhizome source, freshness or dryness and extraction methods. According to the results of this study, the dried ginger rhizome had higher essential oil content than that of fresh ones. For the evaluation of the biochemical attributes of ginger cultivars procured from different states in Nigeria, a very scanty research work has been done. The findings of this investigation on the chemical attributes of dried ginger rhizome powder can be substantiated with the values reported by Ekundayo *et al.* (1988), Onyenekwe and Hashimoto (1999) and Latona *et al.* (2012). In India, Pruthi (1980) reported that dried ginger (*Zingiber officinale* R) contains about 1.5 to 3.5% volatile oil

depending upon varieties. Also, Pruthi (1993) reported the chemical analysis of 26 varieties of ginger grown in India and showed the following range of variations in important quality attributes namely, moisture (8.5-16.5%), volatile oil (1.2 – 2.7%), oleoresin acetone extract (3.9-8.9%), starch (40.4 – 59%), crude fibre (4.79 – 9.80%), crude protein (10.3-15.0%) and total ash (5.12 – 9.28%)ml per 100g of unpeeled ginger.

Sensory analysis of ginger oil and odour characteristics in dried ginger cultivar obtained from seven states in Nigeria was carried out by expert panel of 10 members and table 5 describes the colour of the oil. The colours were found to be pleasing, acceptable, and ranged from golden yellow, pale yellow, very light yellow and light creamish yellow. According to ISO 16928:2014, a pale yellow to amber colour ginger oil have been extracted from China, yellow colour ginger oil from India and pale yellow colour essential oil from West Africa. Other ginger oils with different colours from other regions have been reported (Raina *et al.*, 2005; Stoyanova *et al.*, 2006; Ravi et al., 2013 and Meliani *et al.*, 2014). This shows that the chemical compositions of ginger oils are affected by geographical condition. The other effective factor on chemical composition of oil is the method which is used for extraction of ginger oil, drying method, freshness or dryness and time of exposure of rhizome to heat (Kubra and Rao, 2012). Therefore, defining a protocol for gathering, drying, and extraction method will help to prepare a standard on chemical profile of ginger essential oil by international organization in order to overcome the diversity of chemical composition of essential oil.

The characteristics of the odour/flavor of the ginger oils by expert panel of 10 members were described as camphoraceous, spicy, lemony, aromatic and pungent. The results on the sensory analysis of ginger oil can be collaborated with findings of Ekundayo *et al.* (1988) and Onyenekwe and Hashimoto (1999). Pruthi (1999) reported that essential oil derived from dried ginger, known in trade as oil of ginger is greenish to yellow in colour, mobile with the characteristic warm and aromatic odour. Mathew *et al*. (1973) reported the quality and yield of oil to be 0.90 to 2.5 percent. The odour characteristics were described as citrus lemon odour with mild balsamic, pungent and pleasant smell. The aroma of oil varies with the type of ginger used in distillation. Gopalakrishnam and Narayanan (1991), also reported that solvent partition of ginger oil by batch extractions with hexane/ethanol (70%) solvent system afforded a reasonable good flavor.

CONCLUSION

It could be concluded from above findings that the ginger cultivars grown in different states of the federation are very nutritious and has a great potential for processing and value addition.

Recommendation

Assessment of composition and quality of newly released varieties of ginger grown in other parts of the country is recommended.

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