Diversity of exportable phytochemical traits in ginger from 10 agro-climatic zones of odisha

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ABSTRACT

Ginger (Zingiber officinale), an herb of Asian origin is a valued crop of India, contributes towards 30% of global production. Odisha not only covers the second largest area in ginger cultivation of the country but also exhibits good deal of variability among cultivated germplasm and considered best suitable state after Kerala. To understand the wide range of diversity of exportable phyto-chemical traits like essential oil, oleoresin and crude fibre content, an attempt is taken for the first time in Odisha to analyze hundred twenty germplasm collected judiciously from 30 districts included in 10 agro-climatic zones. When analyzed from all 10 agro-climatic zones, the zone wise highest average oil and oleoresin content showed 2.07% and 8.2% respectively in zone (5) and lowest 0.4% and 4% in zone (8). The lowest average percentage of fibre 6.2% was found in zone (6) and the highest showed 10.25 % in zone (8). This validates the existing practice of large scale cultivation of ginger in zone (5) and (6) and less or no suitability of zone 3 and 8. The percentage variation in quality traits of same known cultivars suruchi, surabhi and suprabha, cultivated in different locations (zone 5,7,9,10) may be attributed to change in the agronomic and agro-climatic conditions like; rainfall, humidity, temperature and geographical features prevalent in respective agro-climatic zones. However, this fact needs further validation by growing same elite cultivars in ten agro-climatic zones of Odisha separately, keeping all agronomic practices unchanged.

KEYWORDS: Diversity, ginger, oil, oleoresin, crude fibre, agro-climatic zone

1. INTRODUCTION

India is a major producer of ginger accounting for about 30% of the global share, followed by China, Nepal and Indonesia. Production of ginger in India during 2012-13 stood at 7.453 lakh ton from an area of 1.578 lakh hectares out of global production of 20.95 Lakh tons (Gracy, 2014) but productivity wise it takes only 17th position 46.867 tons (2012) less than world average of 6.5 tons. There is a good demand for Indian ginger in the global market with a current selling price of around $2800-$2850 per ton (Factfish, 2012). There is 21% reduction in quantity of ginger export from India from 13,625 tons to 10,800 tons during April - December 2012 to April - December 2013 (Spices, 2013). Exports form the most important source of foreign exchange and are a means for mobilising resources for its development plans especially for agrarian based developing country like India. It not only brings in additional foreign exchange for the country but benefits a large number of people involved in the production, processing and exports of such products (Indianspices, 2013). While no efforts should be spared to increase productivity from each hectare of land under cultivation, the marketability or quality of the produce is crucially important. It is, therefore, a matter of survival for us to increase productivity and also maintain the marketability of the produce through improved quality.

The drug yielding potential of ginger is largely due to the presence of phyto-chemical traits like; essential oil, oleoresin and has got worldwide market as it possesses better medicinal properties (Subudhi, 2010). The oleoresin and oil are known as high value and low volume products, which have great demand in western countries. In addition, low fibre containing rhizomes make the variety more industrially suitable, highly exportable and economically viable. Thus the varieties with less fibre, high dry matter recovery and high oil and oleoresin contents are having great export potential in international markets. Therefore, more emphasis is given to develop and market those varieties, which are having the above desired qualities.

Odisha is second largest in production of ginger area wise and also considered as best suitable after Kerala among the states in India (Parthasarathy, 2008) in spite of prevalence of ten different agro-climatic conditions and varied geographical features out of 14 agro-climatic zones found in India. But the quality and productivity of ginger in Odisha has not been surprisingly as per expected and thus the marketability and exportability is affected. Although there are reports on effect of different physical features, climatic conditions on quantity and quality of crop production (Govindarajan, 1982; Lawerence, 1982), no concentrated efforts have so far been made on evaluation of drug yielding potential and exportable traits like high oil, oleoresin and low fibre content of ginger varieties used by farmers in different locality of Odisha.

Studies on genetic variability for yield and associated characters in ginger from India indicated the existence of only moderate to high variability in ginger. The literature pertaining to variability studies in ginger is mainly from India, China, Thailand and Malaysia. Characterization of gingers for morphological, yield and quality parameters displayed moderate diversity in the germplasm assayed (Ravindran, 1994). (Pandey and Dobhal, 1993) highlighted a wide range of variability in ginger for various morphological traits. (Sasikumar, 1992) also investigated 100 ginger accessions and found considerable diversity coupled with significant correlations among different traits. However, no such study on gingers from Odisha is reported so far emphasizing on commercially important traits of ginger like; oil, oleoresin and fibre collected from different agro-climatic zones. The lack of study on gingers from Odisha advocated the need to characterize phyto-chemical diversity profile of this crop. Moreover, to see variability trend in Odisha ginger that was acquired from three sources viz., gene bank, local farmers and market, understanding the spectrum of variability for oleoresin, essential oil and crude fibre content across the state will definitely help boost the ginger productivity and exportability level of the state and country, put ginger production in sound footing.

Present paper deals with evaluation of drug yielding potential and exportability traits of ginger rhizome (oil, oleoresin, crude fibre) from all the states of Odisha and establishing a possible correlation with 10 varied agro-climatic conditions prevailing in the state.

2. MATERIALS AND METHODS

2.1. Sampling of ginger Germplasm from different agro climatic regions of Odisha: Rhizomes of promising cultivars, land races and accessions of ginger used locally by farmers are collected from 10 different agro climatic regions of Odisha (Figure 1), especially from major ginger growing areas with the help of Krishi Vigyan Kendra and OUAT research stations wherever felt necessary from all 30 districts of Odisha and were maintained in field gene banks of Centre of Biotechnology of Siksha 'O' Anusandhan University. Moreover, hundred and twenty ginger accessions including good released varieties like suprabha, suruchi, surabhi (HARS, OUAT, and Pottangi) were used for study (Table 1). Emphasis is given more specifically to individual agro-climatic zones, not only because Odisha has been reported to have ten distinct agro-climatic zones (Table 1) which encompass 30 districts but also due to the fact that the climatic condition has effect on reproduction of quality traits in any crop produce (Govindarajan, 1982; Lawerence, 1982).

2.2. Phyto-chemical evaluation of ginger from different agro climatic regions: Phyto-chemical evaluation of collected ginger rhizomes from different agro climatic zones of Odisha have been done through extraction of oleoresin, essential oil and crude fibre content.

2.1. Extraction of oleoresin: For oleoresin extraction accurately 100 gm of ginger rhizome (from which oil already extracted) was taken. The rhizomes were transferred in extractor (Soxhlet apparatus) by putting cotton in the lower bed. About 250 ml of the acetone was added in the flask and extraction apparatus was assembled. Extraction was continued until the colour of the acetone becomes transparent. After extraction, evaporation of the acetone was done in water bath at 65°C and extract was transferred carefully into the beaker. For complete evaporation of acetone, extract was placed in hot air oven at 75°C for 1 hour (Subudhi, 2010). The final extract found was oleoresin. The percentage of the oleoresin was calculated as: (ASTA, 1978).

$$\text{Oleoresin \%} = \frac{\text{Weight of the residue}}{\text{Weight of the sample}} \times 100$$

2.2. Extraction of essential oil: Essential oil was extracted by hydro-distillation of fresh rhizomes of field grown ginger plants of different agro climatic regions in a Clevenger's apparatus following the method of (Guenther, 1972).

2.3. Estimation of crude fibre: Crude fibre from the powdered ginger sample was estimated by using a Dosi-Fibre apparatus (J.P.Selecta, SPAIN). For determining crude fibre, the organic matter in the dried residue remaining after digesting the sample with distilled sulphuric acid and sodium hydroxide were weighed (Guenther, 1972). For determining the crude fibre content in rhizomes, 2 g of dry ginger powder was extracted in Soxhlets apparatus for 18 hours with petroleum either. The dried material was boiled in 200 ml of H2SO4 (1.25%) for 30 minutes before filtering through muslin cloth and washed with boiling water. The residue was boiled with 200 ml of sodium hydroxide (1.25%) for 30 minutes and filtered through muslin cloth. It was further washed in 2.5 ml of boiling H2SO4 (1.25%) and water. The residue was then transferred to weighing the ashing dish (W1). First, the residue was dried for two hours at 130+20C and weight then taken (W2). After that, it was ignited for 30 minute at 600± 15 0C and was pre weighed (W3). The crude fibre content in ginger rhizome was estimated by using formula suggested by (Maynard, 1970).

$$\text{Crude fibre (\%)} = \frac{(W2-W1)-(W3-W1)}{\text{Wt. of the sample (g)}} \times 100$$

3. RESULTS

A total of 120 number of germplasm collected from different ginger producing pockets of Odisha covering 10 different agro-climatic zones (ACZ). The germplasm collection includes known cultivars Suruchi, Suprabha and Suravi etc. released from the HARS (OUAT), Pottangi, Odisha (Figure 1), few landraces used by farmers and many accessions form local markets at different ginger growing area of Odisha to understand the diversity of marketable traits; essential oil, oleoresin and fibre content in rhizome. The essential oil component imparts the perfumery smell and the aroma whereas the pungency flavour and taste is all due to presence of oleoresin in ginger. Fibre content determines its suitability for industrial processing at commercial scale. The property range, through the analysis of above commercially important traits was found to vary widely across the state.

3.1. Diversity of phyto-chemical traits among ginger variety across Odisha: Out of 120 ginger accessions, highest oleoresin content 11.1% across the state was recorded in (BBL-20) from Keonjhar district and lowest 3.2% was recorded in (BBL-110) from Sonepur district. Highest 3.8 % oil was recorded in (BBL-17) from Keojhar district and lowest was recorded 0.3% in (BBL-101) from kalahandi district. Through analysis of fibre, lowest percentage 4.7 of fibre was recorded in (BBL-37) from Khurda district and highest 11.5 percentage of fibre was recorded in (BBL-94) from Malkangiri district (Table 1).

3.2. Diversity of phyto-chemical traits among ginger variety within agro climatic zone: Odisha is home to diverse climatic, edaphic and geographic conditions. Basing on agro-climatic factors prevailing in the state like; climate, rainfall, humidity, temperature as well as soil type, it is classified into 10 geographically different agro climatic zones. In Odisha ginger is cultivated more or less throughout the state including few highly concentrated pockets of Kandhamal and Koraput area

(Agriexchange, 2012), using different varieties of ginger rhizome as seed. The variability of quality traits of commercial importance at different climatic conditions at different zone was analysed by estimating the oil content, oleoresin and fibre percentage in ginger rhizome collected from ten agro climatic zones covering 30 districts of Odisha (Table 1).

Correlation between performances of a zone with production suitability: Farmers of a locality generally decide the cultivation of a crop which suits well for the locality and produces considerably good amount of produce and/or produce with notable quality traits. This determines the popularity and area of cultivation covering that particular crop in that zone. Therefore, efforts were taken to establish a relationship between the average of quality traits like oil, oleoresin and fibre content found in ginger rhizome of a zone with that of the area of ginger cultivation in all ten separate agro climatic zone (Figure 2).

The range of variability within each zone is presented as follows

Zone [1] Northern Western Plateau: (Sundargarh, parts of Deogarh, Sambalpur and Jharsuguda): The percentage of oleoresin was recorded highest 10% in (BBL-1) and lowest in (BBL-8) 5.4% but in oil was recorded to be highest 2.8% in (BBL-6) and lowest 1.3% in (BBL-2). From fibre analysis it was found to be lowest 5.3% in (BBL-6) and highest 10% in (BBL-2).

Zone [2] North Central Plateau: (Mayurbhanj, major parts of Keonjhar, except Anandapur and Ghasipura block): The percentage of oleoresin was recorded highest oleoresin content 10.2% (BBL-17) and lowest recorded 4.5% (BBL-14). The percentage of oil recorded highest 3.8% in (BBL-17) and lowest 1.2%in (BBL-9). From fibre analysis it was recorded lowest 5.8% in (BBL-12) and highest 9.3% in (BBL-13).

Zone [3] North Eastern Coastal Plain:(Balasore, Bhadrak, parts of Jajpur and Hatidihi block of Keonjhar): The percentage of oleoresin was highest recorded in (BBL-20) 11.1% and lowest in (BBL-27) 5.6%. The percentage of oil recorded highest 3% in (BBL-20) and lowest 1.2%in (BBL-21). From fibre analysis it was recorded lowest 4.2% in (BBL-21) and highest 9.5% in (BBL-23).

Zone [4] East and South Eastern Coastal Plain: (Kendrapara, Khurda, Jagatsinghpur, Cuttack, Puri, Nayagarh & Ganjam): The percentage of oleoresin was highest in (BBL-37) 9.2%and lowest in (BBL-35) 4.6%. The percentage of oil recorded highest 3.2% in (BBL-37) and lowest in (BBL-33) 1.2%. From fibre analysis it was recorded highest 9.6% in (BBL-33) and lowest 4.7% in (BBL-37).

Zone [5] North Eastern Ghat: (Phulbani, Rayagada, Gajapati, part of Ganjam & small patches of Koraput): The percentage of oleoresin was highest 10.2% (BBL-50) lowest 3.6% in (BBL-61), The percentage of oil recorded highest 3.6% in (BBL-45&48) and lowest in (BBL-39) 0.8% . From fibre analysis it was recorded lowest 4.5% in (BBL-53) and highest 10.6% in (BBL-64).

Zone [6] Eastern Ghat High Land:(Major parts of Koraput, Nabarangpur): The percentage of oleoresin was highest 9.1% in (BBL-87) lowest 4.1% in (BBL-78), The percentage of oil recorded highest 2.7% in (BBL-82) and lowest in (BBL-79) 1.1% .From fibre analysis it was recorded lowest in (BBL-78) 4.6% and highest 8.7% in (BBL-83).

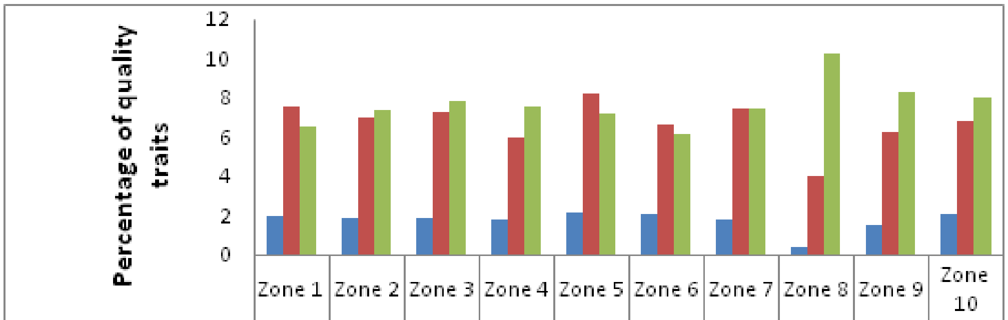
Zone [7] SOUTH EASTERN GHAT: (Malkangiri & part of Koraput): The percentage of oleoresin was recorded highest 9.9% (BBL-92) and lowest recorded 5% (BBL-98). The percentage of oil recorded highest 2.9% in (BBL-90) and lowest in (BBL-93) 1.5%. From fibre analysis it was recorded lowest 4.9% in (BBL-99) and highest 11.5% in (BBL-94).

Zone [8] Western Undulating Zone: (Kalahandi & Nuapada): The percentage of oleoresin was highest 4.2% in (BBL-102) and lowest in (BBL-101)3.8%.The percentage of oil was recorded highest 0.5% in (BBL-102) and lowest 0.3% in (BBL-101). From fibre analysis it was recorded lowest 9.9% in (BBL-102) and highest 11% in (BBL-101).

Zone [9] Western Central Table Land: (Bargarh, Bolangir, Boudh, Sonepur, parts of Sambalpur & Jharsuguda): The percentage of oleoresin showed highest 8.4% in (BBL-112) and lowest 3.2% in (BBL-110).The percentage of oil recorded highest 2.8% in (BBL-112) and lowest 0.9% in (BBL-107). From fibre analysis it was recorded lowest in (BBL-107) 5.9% and highest 11.2% in (BBL-106).

Zone [10] Mid Central Table Land: (Angul, Dhenkanal, parts of Cuttack & Jajpur): Oleoresin content was recorded highest 8.5% in (BBL-118) and lowest was recorded 5.1% in (BBL-116).The percentage of oil recorded highest 3.1% in (BBL-118) and lowest 1.2% in (BBL-116). From fibre analysis it was recorded lowest 5.1% in (BBL-118) and highest 10% in (BBL-119).

3.3. Diversity of Phytochemical traits of known cultivars at different locations: Cultivation of few known cultivars Suruchi, Suprabha and Suravi etc. released from the HARS (OUAT), Pottangi, Odisha, as well as from ginger growers of few more locations. The quality traits (oil, oleoresin, fibre content) analysis of known ginger cultivars cultivated in more than one distantly located place or rather in different agro climatic zones was recorded to find if at all there occurred any change in their content because of change in agro-climatic conditions. (Table 1).



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10
% of essential oil	2.02	1.92	1.925	1.79	2.14	2.03	1.8	0.4	1.52	2.1
% of oleoresin	7.52	6.97	7.25	5.94	8.2	6.58	7.45	4	6.27	6.8
% of fibre	6.5	7.37	7.8	7.6	7.17	6.2	7.5	10.25	8.31	8.05

Figure.1.Average of quality traits of ginger sample of individual agro-climatic zones

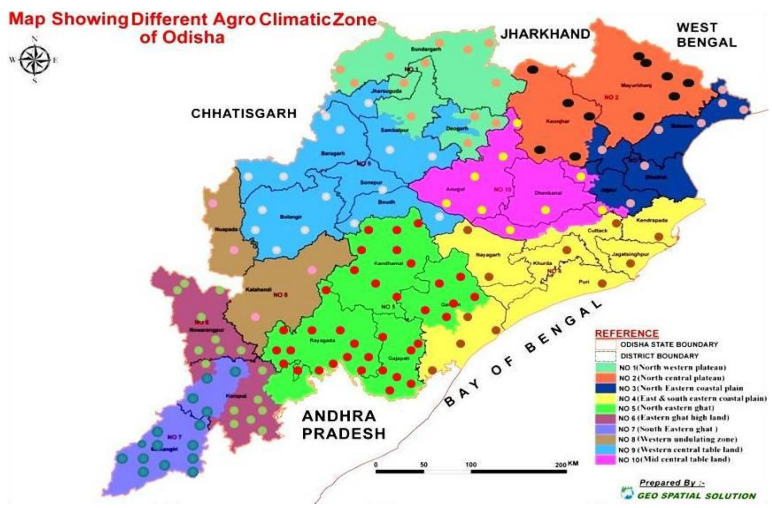


Figure.2.Ten Agro Climatic Zones of Odisha marked with place of ginger sample collection

4. DISCUSSION

For clonally propagated crops like ginger, the species and varietal diversity are important components of biodiversity as it allows selection forces to act on it (Sasikumar, 1999). The long history of domestication of gingers into diverse geographical niches might have played a major role in the evolution of this crop. However, variability tends to limit in cultivars grown in the same region compared to the ones growing in geographically distant locations (Ravindran, 2005).

4.1. Diversity of phyto-chemical traits among ginger variety across Odisha

The phyto-chemical trait analysis showed a higher range of variability in quality parameters of ginger sampled throughout Odisha. When analyzed from all 10 ACZ, the highest average oleoresin content showed 8.2% in zone [5] and lowest 4% in zone [8]. The highest average of oil percentage was recorded 2.07% in zone [5] and lowest 0.4% in zone [8]. The lowest average percentage of fibre 6.2% was found in zone [6] and the highest showed 10.25%in zone [8]. From the average oil and oleoresin analysis of the state, it is clear that zone [5] and [6] produces good quality ginger as their rhizome contains considerably good amount of oil and oleoresin and less fibrous respectively. This report however may be correlated with area of cultivation and productivity as in Table 1. These zones with Kandhamal and koraput as their major centres have been accepted and known to produce good quality and quantity of ginger (Agriexchange, 2012). The ginger cultivation has been found to be poor and the productivity is reported to be the lowest in the zone [8] as shown in Table 1. Probably that might be the reason the rhizome sample collected from these zones shows lowest percentage of oil and oleoresins and also less preferred highly fibrous rhizomes (never enlisted as major ginger cultivating regions of Odisha) (Agriexchange, 2012). However, participation of educated farmers and implementation of good agricultural practises cannot be ruled out in zone [5] and on the other hand, unsuitable climatic conditions at zone [8] may be reasoned for its disadvantageous status of ginger cultivation.

Table.1. Diversity of Phyto-chemical traits of 120 ginger germplasm collected from 10 Agro Climatic Zone (ACZ) of Odisha

CZ	Acc.No.	Essential oil(%)	Oleoresin %	Fibre %	ACZ	Acc.No.	Essential oil (%)	Oleoresin %	Fibre %	ACZ	Acc.No.	Essential oil (%)	Oleoresin %	Fibre %
[1] NORTH WESTERN PLATEAU (Sundargarh, parts of Deogarh, Sambalpur & Jharsuguda)	BBL-1	1.7	10	5.8	[5] NORTH EASTERN GHAT (Phulbani, Rayagada, Gajapati, part of Ganjam & small patches of Koraput)	BBL-41	1.4	8.6	6.5	[6]EASTERN GHAT HIGH LAND (Major parts of Koraput, Nabarangpur	BBL-81	2.3	7	6.3
	BBL-2	1.3	5.7	10		BBL-42	1.2	7.8	10		BBL-82	2.7	4.6	5.6
	BBL-3	1.9	6.9	6.9		BBL-43	2.7	8.2	9.2		BBL-83	2.1	6.6	8.7
	BBL-4	2.7	9.6	7.2		BBL-44	2.4	8.1	8.5		BBL-84	2.6	6.7	6.4
	BBL-5	1.9	6.7	7.6		BBL-45	3.6	7.6	6.8		BBL-85	2.4	7.6	6.2
	BBL-6	2.8	6	5.3		BBL-46	3	8.7	5.8		BBL-86	1.5	7.2	6.6
	BBL-7	1.5	7.2	6.1		BBL-47	2.9	9.1	5		BBL-87	2.5	9.1	5.2
	BBL-8	2.5	5.4	7.5		BBL-48	3.6	7.9	4.8	[7] SOUTH EASTERN GHAT (Malkangiri & part of Keonjhar)	BBL-88	1.8	9.4	8.9
[2] NORTH CENTRAL PLATEAU (Mayurbhanj, major parts of Keonjhar, except Anandapur & Ghasipura block)	BBL-9	1.2	6.6	8.1		BBL-49	2.1	6.5	5.2		BBL-89	2.1	9.2	7.8
	BBL-10	1.8	7.3	7.4		BBL-50	2.7	10.2	6		BBL-90	2.9	9.7	6.9
	BBL-11	1.4	4.7	6.9		BBL-51	2.5	9.7	8		BBL-91	2.2	5.2	5.3
	BBL-12	1.4	6	5.8		BBL-52	1.6	8.6	6.3		BBL-92	2.3	9.9	6.3
	BBL-13	1.9	8.5	9.3		BBL-53	1.3	7.2	4.5		BBL-93	1.5	5.7	6.2
	BBL-14	1.3	4.5	6.2		BBL-54	1.8	9.3	5.2		BBL-94	1.9	8	12
	BBL-15	2.3	6.6	7.8		BBL-55	1.6	5.6	6.6		BBL-95	1.8	8.6	7.5
	BBL-16	2.3	8	8.9		BBL-56	3	7.5	5.4		BBL-96	2	8.9	6.1
	BBL-17	3.8	10.2	7.2		BBL-57	2.4	6.2	8.3		BBL-97	1.8	9	8.1
	BBL-18	1.8	7.35	6.1		BBL-58	1.3	7.1	7.7		BBL-98	1.9	5	5.3
	BBL-19	1.5	5.8	6		BBL-59	2.5	8.8	6.4		BBL-99	2.1	5.9	4.9
[3] NORTH EASTERN COASTAL PLAIN (Balasore, Bhadrak, parts of Jajpur & hatdihi block of Keonjhar)	BBL-20	3	11.1	5.3		BBL-60	2	6.3	6.2		BBL-100	1.8	6.6	5.6
	BBL-21	1.2	5.7	4.2		BBL-61	2.3	3.6	7.1	[8] WESTERN UNDULATING ZONE (Kalahandi & Nuapada)	BBL-101	0.3	3.8	11
	BBL-22	1.7	6.6	9		BBL-62	2.1	8.5	9.2		BBL-102	0.5	4.2	9.9
	BBL-23	1.4	6	9.5		BBL-63	1.6	9.9	8.7	[9] WESTERN CENTRAL TABLE LAND (Bargarh, Bolangir, Boudh, Sonepur, parts of Sambalpur & Jharsuguda)	BBL-103	1	5.9	7.5
	BBL-24	2.2	8.3	8.8		BBL-64	2.5	9.1	11		BBL-104	1.3	7.1	9.3
	BBL-25	2	7.6	8.4		BBL-65	2.1	8.9	9.2		BBL-105	1.5	5.9	8.5
	BBL-26	1.5	7	9.2		BBL-66	2.2	8	7.5		BBL-106	1	5.6	11
	BBL-27	1.8	5.6	8		BBL-67	1.8	8.6	7.8		BBL-107	0.9	5.6	5.9
[4] EAST AND SOUTH EASTERN COASTAL PLAIN (Kendrapara, Khurda, Jagatsinghpur, Cuttack , Puri, Nayagarh &	BBL-28	2.5	7.8	5.2		BBL-68	1.5	8.5	8.3		BBL-108	1.7	6	9.1
	BBL-29	1.3	5.3	8.6		BBL-69	2	9	6.1		BBL-109	2	5.5	8.6
	BBL-30	2.2	6.2	8		BBL-70	2.1	8.6	7.1		BBL-110	1.2	3.2	8.5
	BBL-31	2	6.5	9		BBL-71	1.8	9.5	7.4		BBL-111	1.9	6.5	8
	BBL-32	1.4	5.3	9.3		BBL-72	1.5	8.5	8		BBL-112	2.8	8.4	6.5
	BBL-33	1.2	5.1	9.6		BBL-73	2.4	8.4	6.5	[10] MID CENTRAL TABLE LAND (Angul, Dhenkanal, parts of Cuttack & Jajpur)	BBL-113	2.4	7	9.3
	BBL-34	2	5.5	7.8		BBL-74	2.2	8.2	6.3		BBL-114	2.6	7.8	6.5
	BBL-35	1.8	4.6	9.5		BBL-75	1.8	7.4	6.1		BBL-115	1.8	5.8	6.6
	BBL-36	2	5.2	4.9		BBL-76	1.7	8.1	4.6		BBL-116	1.2	5.1	9.8
	BBL-37	3.2	9.2	4.7	6	BBL-77	1.4	7.1	6.9		BBL-117	1.7	5.4	8.9
5	BBL-38	1.7	9	9.3		BBL-78	1.9	4.1	4.6		BBL-118	3.1	8.5	5.1
	BBL-39	0.8	8.9	6.9		BBL-79	1.1	7.5	5.3		BBL-119	1.4	8	10
	BBL-40	2	6.3	7.8		BBL-80	1.5	8.6	5.6		BBL-120	1.9	5.3	8.2

4.2. Diversity of phyto-chemical traits within agro climatic zone and production suitability

A good range of diversity within agro-climatic zone has been reported as learnt from the analysis of three quality exportable traits oil, oleoresin and fibre content details of which is given in Table 2. From the average performance of individual zone as compared to state average production percentage in oil (1.76), oleoresin (6.698) and fibre content (7.675), all the ten zones may be arbitrarily categorized into three groups: zones 8 and 9 as below average, zone 4 and 7 as average and rest of the zones 5, 6, 10, 1, 2, and 3 as above average in production of quality traits (Figure 1). Suitability of ginger production (Table 1) may be correlated with quality performance of a zone (Figure 1). Highlights of GIS based analysis for suitability for ginger production in Odisha also match with our inference that zone 5, 6,10 are more suitable than other zones and zone 3 and 8 are least or not suitable (Parthasarathy, 2008; Mohanty and Panda, 1994) are also of opinion that as of the average, lowest and highest in phyto-constituents level in zones show some of the suitability within Odisha for ginger production, which areas have the suitability for ginger cultivation with some good released variety. However, role of no uniformity in use of elite ginger cultivars and non-following of advanced agronomic practices in these zones resulting in overall low productivity of the state cannot be ruled out while establishing the correlation.

4.3. Phytochemical diversity of known cultivars at different locations

While collection of ginger rhizome sample from across the state, along with many local landraces and accessions, few known cultivars Suruchi, Suprabha and Suravi etc released from research station of Odisha HARS, Pottangi, Koraput were being cultivated by ginger growers at many locations from separate agro climatic zones. The percentage of oil, oleoresin and fibre content of these varieties cultivated at different locations showed variation as given in Table 1. The percentage of these quality traits as given in Table found to differ also from the analysis report of released varieties Suruchi, Suravi and Suprabha as depicted earlier (Ravindran and Nirmal babu, 2005). The variation in the percentage content of quality traits may be attributed to change in the location. There are many factors which are changeable with the change of location leading to alteration in agro climatic conditions like; rainfall, humidity, temperature and geographical features prevalent in respective agro-climatic zone. Earlier report support the fact that changes in agro-climatic conditions and geographical features affects the quantitative and qualitative traits of any crop (Govindarajan, 1982; Lawerence, 1982). However, other valid reasons for disproportionate in productivity and change in quality of produce may be many as follows; majority of tribal or rural farmers lack improved production technologies and adequate agriculture management practices (Misra, 2003; Parthasarathy, 2008). Because the majority of best ginger growing area is high terrain or the size of land holding is very small in the region, the commercialization of crop/variety on large scale is very difficult in the region. Though many high yielding varieties have been identified and recommended by the researchers in the region and already in practice but quality seed production in a large scale is lacking due to non-existence of agencies responsible for quality seed production (Non-availability of quality planting materials and other inputs) and lack of funds and awareness ends up in low fertilizer and pesticide usage. In addition, the problems entangled with processing and marketing of ginger in the state due to non-topping of value added products like oleoresin, volatile oils, etc., losses due to faulty storage method and diseases like rhizome rot and lack of trained personnel with sound knowledge in post-harvest technologies cannot be forgotten while attributing the reasons of low productivity of ginger in Odisha. Many of above mentioned reasons are same for today's' fate ginger cultivation of north east region of the country, although the climatic condition is favorable for the crop (Yadav, 1999). Although, Odisha is understood to be suitable for ginger crop production and with proper technology transfer, it can became one of the highest ginger producing states in India (Parthasarathy, 2008) and has got highest land coverage for ginger in the country, many elite cultivars released from HARS (OUAT), Pottangi research station, even few germplasm show good amount oil and oleoresin many of them are very high in fibre content making it unsuitable for commercialization during value addition and make them non exportable (Yadav, 1999).

The above findings advocate further more intensive research is needed so that overall scenario of the ginger production of the state can be changed by increasing production and productivity of ginger in Odisha. There is need for survey and diagnosis of lands suitable for ginger following GIS system, large scale introduction of indigenous and exotic high yielding strains of ginger suitable for the state. Breeding should be done for high yielding and better quality varieties with resistance to biotic and abiotic stress. The cost benefit analysis of different farming systems is required. There is immense need to strengthen the extension system for transfer of technologies generated and providing training to the farmers (Yadav, 1999). Before concluding anything, effect of agro-climatic conditions on quantitative and qualitative traits of ginger should be studied using elite cultivars keeping all agronomic practices unchanged in ten agro-climatic zones of Odisha separately and suitability of a particular cultivar for a locality may be found out. The authors are however engaged presently in carrying out some experiments to find out answer for last to objectives.

5. CONCLUSION

Various known cultivars of ginger were collected from different agro climatic zones exhibits diversification in phytochemical traits like essential oil, oleoresin, and fiber. For further evaluation in the diversification for phytochemical of ginger GC-MS analysis and Molecular aspects can be carried out to know the proper identification within the cultivar level.

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