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UALITY EVALUATION IN GINGER (*ZINGIBER OFFICINALE* ROSC.) IN RELATION TO MATURITY*

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ABSTRACT

Yield of rhizomes (fresh and dry weight) as well as quality parameters like essential oils, oleoresin, gingerol, starch, protein and fibre were determined for 14 popular cultivars of ginger (*Zingiber officinale* Rosc.) at 150, 180, 210 and 240 days (full maturity) after planting. The maximum yield of fresh and dry weight of rhizome was obtained in cultivars 'Nadia' and 'Maran'. Though the percentage of essential oils and oleoresin decreases with increasing maturity, the final yield per hectare of these two quality components were maximum at full maturity. Cultivars 'Maran', 'Ernad Chernad' and 'Nadia' are recommended for fresh rhizomes and 'Maran', 'Ernad Chernad', 'Karakkal' and 'Nadia' are recommended for the production of dry ginger. Correlation matrix involving maturity and percentage dry recovery, essential oils, oleoresin, gingerol and crude fibre are described.

INTRODUCTION

India produces an average of 80,000 onnes of dry ginger annually out of which about 15,000 tonnes are exported. While the consumption within the country is either in the form of fresh or dry ginger, the end use in the importing countries is in the form of oleoresin or essential oils of ginger.

While dry ginger appearance is important to fetch a premium price, essential oils, oleoresin and gingerol imparting flavour, aroma and pungency respectively and starch, protein and crude fibre making the bulk of the dry matter and body of the ginger are important quality attributes (Govindarajan, 1982). The yield at present is assessed based on the dry rhizomes obtained. The quality of the final product depends upon a number of factors, the most important among them being the cultivar. There is an increasing tendency at present to export the end products like ginger oils and oleoresin and in view of this, a need arises to estimate the maximum yield of quality components in ginger at different stages of maturity.

The changes in crude fibre, fat and protein contents in 13 cultivars of ginger at different maturity periods were reported by Jogi et al. (1972). Natarajan et al. (1972) reported increase in contents of quality parameters during September-December of the cropping season. Jayachandran, Vijayagopal and

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Sethumadhavan (1980) found 7 months maturity as optimum for extracting oleoresin and volatile oil in cultivars Rio de Janeiro. Maurya, Jha and Chandany (1984) confirmed these findings subsequently.

The changes in quality parameters at four stages of maturity in 14 popular cultivars of ginger are reported in this paper.

MATERIALS AND METHODS

Among 124 accessions of ginger available in the germplasm bank at the National Research Centre for Spices, Calicut, 14 cultivars were selected for the study. The recommended manurial and cultivation practices were followed and rhizome samples were collected for analysis at 150, 180, 210 and 240 days after planting. After recording the green rhizome weight, the samples were dried in the cross flow air oven at 50 ± 2°C. The percentage of dry weight to fresh weight was calculated and expressed as percentage dry recovery. Essential oil was extracted using Clevanger's distillation still lighter than water type (AOAC, 1975) and oleoresin was extracted with acetone by cold percolation. Gingerol in oleoresin was estimated by ISI method (1976). Starch percentage was estimated as per the method of Neilson (1962) and protein using the method of Sedmak and Grossberg (1977). Crude fibre was determined by AOAC method (1975). All the chemical quality constituents are expressed on dry weight basis.

RESULTS AND DISCUSSION

Percentage of dry recovery, essential oil, oleoresin, gingerol, starch, protein and fibre contents are presented in Table I, and calculated yield of fresh and dry rhizome weights, essential oil and oleoresin in kg/ha, are presented in Table II. As expected, a gradual increase in yield of fresh rhizome was observed from 150th day onwards in all cultivars, the maximum being at full maturity. The yield of fresh rhizome varied from 12,644 kg in cultivar 'Narasapattom' to 22,140 kg/ha in 'Nadia' at 240th day. The percentage dry recovery was maximum at 240th day and varied from 14.86% in 'No. 646' to 22.2% in 'Nadia'. Sreekumar, Indrasenan and Mammen (1980) found the dry recovery ranging from 17.7% in 'China' to 28.0% in 'Tura' among 30 ginger cultivars estimated by them. Muralidharan (1972) reported dry recovery of 22.07% in 'Tura' among 12 ginger cultivars and Muralidharan and Ramankutty (1975) observed dry recovery of 23.3% in 'Nadia'. The data indicates that cultivars 'Maran', 'Ernad Chernad' and 'Nadia' are suitable for the production of fresh ginger. Based on the dry recovery percentage estimated in the present analysis 'Maran', 'Ernad Chernad', 'Nadia' and 'Karakkal' are recommended for the production of dry ginger. Sreekumar et al. (1980) and Muralidharan and Ramankutty (1975) also recommended 'Maran' and 'Nadia' for production of dry ginger.

Essential oils

The essential oil content at the final harvest (240th day) varied from 1.2% in 'Arippa' to 2.5% in 'China'. Even-though the essential oil content was more during the initial stages of growth,

per hectare yield was maximum at full maturity in all the cultivars except in Jamaica, 'cv. 646' and 'Arippa'. Among 25 ginger cultivars studied by Nybe, Sivaraman Nair and Mohanakumaran (1980), cv. 'Karakkal' contained highest essential oil content of 2.4%. The essential oil level in ginger generally varied from 1.5% to 2.5% (Natarajan and Lewis, 1980). A wide range of 0.8-4.4% essential oil is reported by Connell (1970) from the ginger grown in Australia, India, Africa and Jamaica. Lewis et al. (1972) observed a variation of essential oil from 0.9 ('Tura') to 2.1% ('Maran') among 27 cultivars. Natarajan et al. (1972) observed a minimum oil content (1.0%) in 'Nadia' and maximum 2.7% in 'Mysore' among 26 cultivars analysed by them.

Oleoresin

The oleoresin percentage was generally maximum in immature crop (*i. e.*, 150th day) in all the cultivars except in 'Maran' and CV 646 and thereafter the tendency was to decrease steadily with maturity. This is in conformity with the earlier reports (Aiyadurai, 1966; Mathai, 1975; Jayachandran et al., 1980; Maurya et al., 1984). The calculated yield of oleoresin per hectare (Table II) is maximum in all the cultivars at 240th day inspite of the decreasing percentage of oleoresin. This is understandable since the fresh as well as dry weight of rhizome increase rapidly after 150th day. In view of this though the percentage of oleoresin is maximum during the initial period of growth, it is advisable to harvest the crop at full maturity to obtain maximum yield of oleoresin/ha. Among different cultivars, the maximum oleoresin per hectare at 240th day was in cultivar 'Nadia' (336.68 kg) followed by 'Ernad Chernad' (312.82 kg) and 'Maran' (272.14 kg). Generally the oleoresin content varied from 4 to 6% (Natarajan and Lewis, 1980). Nybe et al. (1980) observed a significant variation in oleoresin content in 25 ginger cultivars, maximum (10.5%) being in 'Rio de Janeiro' followed by 'Maran' (10.0%). Sreekumar et al. (1980) observed a wide variation in oleoresin content in 30 ginger cultivars and the range of variation was observed to be 3.0% ('Poona') to 10.8% ('Rio de Janeiro'). According to Mathai (1975) oleoresin content decreased with maturity which is broadly in conformity with the present study.

Gingerol in ginger oleoresin

The pungent principle in ginger is gingerol and the estimation of gingerol presented in Table I shows that it varies from 9.10% in 'Vengara' Selection to 28.05% in 'Jugijan' in different cultivars at varying maturity. Natarajan and Lewis (1980) reported 18 to 20% gingerol in oleoresin though they did not mention the cultivar. There seems to be a concentration of gingerol in oleoresin about a month before the rhizome reaches full maturity (between 180 and 210 days) in majority of the cultivars except in, 'No. 646' 'Ernad Chernad', 'Sleeva local' in which the gingerol content was maximum at full maturity.

Starch

Starch, the dominant constituent

Table I. *Percentage dry recovery, essential oil, oleoresin, gingerol, starch, protein*

Sl. No.	Cultivar	Maturity (in days) period	Dry recovery	Essential oil	Oleoresin	Gingerol in oleoresin	Starch	Protein	Fibre
1	2	3	4	5	6	7	8	9	10
1.	Maran	150	8.60	3.5	6.60	18.50	26.10	12.43	2.20
		180	10.89	3.2	7.90	19.25	26.23	13.53	3.47
		210	16.29	2.1	8.06	22.74	32.20	8.41	4.32
		240	20.40	2.0	6.85	19.25	44.62	8.46	5.85
2.	Jugijan	150	7.52	3.0	9.70	18.48	24.90	11.70	1.95
		180	13.10	2.5	5.60	22.45	24.35	7.31	3.80
		210	14.72	1.6	3.60	28.05	31.02	8.78	4.46
		240	15.85	1.5	5.50	18.51	41.75	6.77	5.98
3.	No. 646	150	7.90	3.2	6.40	11.80	20.60	12.80	2.49
	(Himachal	180	8.29	3.0	7.10	21.32	20.71	13.53	3.64
	Pradesh)	210	10.84	2.4	8.39	18.25	35.70	6.76	4.50
		240	14.86	1.5	8.59	21.31	49.66	8.75	5.25
4.	Arippa	150	9.80	3.0	7.30	18.60	27.60	12.80	2.86
		180	12.17	2.2	6.28	24.00	29.07	12.95	3.37
		210	15.63	2.1	6.42	16.44	32.48	12.62	4.90
		240	16.38	1.2	6.65	15.89	40.34	9.32	5.13
5.	Vengara	150	7.18	3.0	10.40	9.10	29.90	11.30	2.58
	Selection	180	9.46	2.8	8.53	18.16	32.35	14.81	4.00
		210	12.16	2.5	6.67	23.83	33.92	11.13	5.63
		240	19.85	1.5	7.23	16.09	46.40	9.15	5.92
6.	Ernad	150	8.77	4.0	8.00	14.86	27.80	14.80	2.90
	Chernad	180	11.93	2.8	7.60	15.85	31.19	11.83	3.56
		210	16.00	2.5	6.67	22.88	29.06	7.40	5.47
		240	20.17	2.0	8.10	24.66	44.32	7.86	6.20
7.	Rio-de-	150	8.00	3.5	9.50	19.50	27.84	12.86	2·89
	Janeiro	180	10.00	2.5	7.35	16.75	29.68	13.90	3.50
		210	13.50	1.8	7.50	22.50	33.00	9.42	5.00
		240	18.75	2.0	7.00	24.84	47.00	8.40	5.26
8.	Jamaica	150	8.40	2.6	8.40	19.60	21.80	10.40	1.85
		180	13.59	3.0	5.35	20.00	22.21	12.98	3.46
		210	17.24	2.4	5.39	27.08	34.32	8.59	4.24
		240	19.00	2.0	5.37	26.67	49.00	6.95	4.85
9.	Sleeva Local	150	11.10	4.2	9.00	18.10	22.60	11.80	2.86
		180	12.94	2.8	6.62	24.00	29.30	6.77	4.49
		210	18.75	1.9	4.61	20.88	39.92	7.13	6.58
		240	20.05	2.0	7.36	22.82	45.19	8.14	6.90

d fibre in 14 cultivars of ginger at different maturation periods

2	3	4	5	6	7	8	9	10
Nadia	150	10.50	2.5	7.00	27.80	21.80	12.60	3.00
	180	13.00	2.4	6.49	26.06	23.90	13.90	4.20
	210	15.77	1.6	5.10	23.66	36.34	6.95	5.10
	240	22.20	1.5	6.85	20.09	46.72	9.33	6.85
Narasapattom	150	7.90	3.0	6.20	12.80	21.60	11.80	2.56
	180	8.70	2.8	5.35	20.58	27.52	13.53	3.00
	210	12.98	1.6	5.21	21.90	30.73	8.75	4.50
	240	15.06	2.0	6.50	18.91	41.16	6.40	5.54
Karakkal	150	9.17	3.0	8.10	18.50	17.10	12.80	2.40
	180	11.60	2.4	7.17	27.50	22.51	13.50	4.00
	210	17.45	1.6	6.61	25.16	38.36	8.45	5.75
	240	20.50	2.0	7.75	20.65	49.72	9.17	6.01
Wynad Local	150	10.12	3.0	9.20	12.80	23.60	11.80	2.56
	180	11.60	3·0	5.35	20·58	24.52	13.53	5.50
	210	17.52	1.8	5.21	21.90	30.76	8.78	5.87
	240	20.64	2.0	5.30	17.71	41.15	6.40	6.54
China	150	10.00	3.0	7.30	27.80	27.30	12.60	1.75
	180	13.49	2:6	5.15	20.40	23.92	13.90	3.08
	210	17.21	2.5	6.58	25.15	33.08	5.49	3.76
	240	18.50	2.5	6.03	20.12	42.15	8.41	4.98

nd an index to maturity increased in ll the cultivars with maturity. The naximum starch content at full maturity aried from 40.34% (in 'Arippa') to 9.72% (in 'Karakkal'). Jayachandran t al. (1980) and Maurya et al. (1984)also eported an increase in starch content vith increasing maturity in cultivar 'Rio le Janeiro'. Natarajan et al. (1972) bserved maximum starch content of 9% in 'Nadia' and a minimum of 40.4% n cv. 'Assam'.

Protein

Protein content reaches the maximum at 180th day in almost all the cultivars except in 'Jugijan', 'Ernad Chernad' and 'Sleeva Local' and thereafter decreasing rapidly. Jogi et al. (1972) also reported a similar trend in protein content in different maturation periods in 14 cultivars of ginger. According to them, the protein content at full maturity varied from 4.21% in 'Wynad Local' to 9.29% in 'Rio de Janeiro'. However, Natarajan et al. (1972) reported a higher protein content which varied from 10.3% (in 'Assam') to 15.0% (in 'Manjeri') among 26 cultivars analysed.

Crude fibre

Crude fibre content also increased with increasing maturity. This is in

Table II. *Calculated projected yield (kg/ha) in 14 cultivars of ginger with respect*

Sl. No.	Cultivar	Maturity period (in days)	Fresh weight	Dry weight	Essential oil	Oleoresin
1	2	3	4	5	6	
1.	Maran	150	8241.00	708.73	24.80	46.78
		180	11996.60	1306.43	41.80	103.21
		210	14038.40	2286.85	48.02	156.65
		240	19475.00	3972.90	79.46	272.14
2.	Jugijan	150	8068.80	606.77	18.20	58.86
		180	10906.00	1428.69	35.72	80.01
		210	12513.20	1841.94	29.47	72.94
		240	14735.40	2335.56	35.03	128.45
3.	No. 646 (Himachal Pradesh)	150	8175.40	645.85	20.67	41.33
		180	10364.80	859.24	25.78	61.00
		210	12406.60	1344.87	32.28	112.83
		240	17835.00	1486.00	22.29	127.65
4.	Arippa	150	7585.00	544.60	16.34	53.37
		180	9036.40	1099.73	24.19	69.05
		210	11963.80	1869.94	39.26	120.06
		240	15227.40	2494.25	29.93	165.87
5.	Vengara Selection	150	7773.60	588.29	16.75	58.06
		180	8200.00	755.72	21.70	66.17
		210	11816.20	1436.85	35.91	98.69
		240	13981.00	2775.23	41.63	200.65
6.	Ernad Chernad	150	8298.40	727.77	29.11	58.23
		180	10250.00	1222.82	34.24	92.93
		210	14678.00	2348.48	58.71	155.64
		240	19147.00	3861.95	77.24	312.82
7.	Rio-de-Janeiro	150	9167.60	733.00	25.67	69.63
		180	11665.00	1166.50	29.16	85.74
		210	13120.00	1771.20	31.88	132.84
		240	17220.00	3228.00	64.56	225.94
8.	Jamaica	150	10045.00	843.78	21.94	70.88
		180	12332.80	1676.03	50.28	89.67
		210	15170.00	2615.31	62.77	146.19
		240	16416.40	3118.93	62.38	167.49
9.	Sleeva Local	150	7699.80	854.68	35.89	53.89
		180	9725·20	1258.44	35.24	64.38
		210	11890.00	2229.37	42.55	102.77
		240	13940.40	2794.97	55.89	205.71

resh weight, dry weight, essential oil and oleoresin

2	3	4	5	6	
Nadia	150	10537.00	1106.39	27.66	77.45
	180	11693.20	1520.12	36.48	98.65
	210	16186.80	2552.66	40.84	130.18
	240	22140.00	4915.08	78.73	336.68
Narasapattom	150	6560.00	513.20	15.55	32.19
	180	9380.80	816.30	22.85	43.66
	210	11127.40	1444.34	23.11	75.24
	240	12644.40	1904.25	38.08	128.78
Karakkal	150	8232.80	754.95	23.55	61.15
	180	10955.20	1270.80	38.12	91.12
	210	12857.60	2243.65	35.89	148.30
	240	16810.00	3446.05	68.92	267.07
Wynad Local	150	9471.00	958.46	28.75	88.18
	180	11890.08	1379.24	41.38	73.79
	210	13792.40	2416.43	43.49	125.89
	240	16400.00	3384.95	67.69	179.40
China	150	5740.00	5740.00	17.22	41.90
	180	9864.60	1330.13	34.59	68.50
	210	13161.00	2265.01	56.64	149.04
	240	14117.40	2741.22	68.54	165.29

conformity with the findings of Jogi et al. (1972), Jayachandran et al. (1980) and Maurya et al. (1984). However, Mathai (1975) observed a decreasing value in crude fibre content during maturity in seven ginger cultivars studied by him. Sreekumar et al. (1980) reported a minimum crude fibre content of 3.5% in 'Tura' and maximum of 6.0% in 'Jorhat'. Muralidharan (1974) reported a lower fibre content of 4.23% in 'Himachal Pradesh' and maximum of 8.44% in 'Thodupuzha'. The present investigation indicated that minimum crude fibre content was in 'Jamaica' (4.85%) and maximum (6.90%) in 'Sleeva Local.'

Correlation between quality parameters

Correlation between different quality parameters is given in Table III. With the advent of maturity of ginger, percentage dry recovery, starch and crude fibre increase and the correlation between percentage dry recovery and starch and crude fibre is statistically significant. The levels of the essential oil, oleoresin and protein decrease significantly as maturity progresses. Accumulation of dry matter and fibre during growth and development reported earlier (Mathai, 1975) is in conformity with the results obtained in the present studies. A reduction in the oleoresin content is

Table III. *Correlation matrix*

	Maturity	Dry recovery	Essential oil	Oleoresin	Gingerol	Starch	Protein	Fibre
Maturity	I	0.8907**	-0.8134**	-0.3515*	0.2699	0.8868**	-0.7083**	0.8668**
Dry recovery		I	-0.7238**	-0.3901**	0.3412*	0.8128**	-0.6940**	0.8305**
Essential oil			I	0.4045**	-0.3249*	-0.6903**	0.6254**	-0.7119**
Oleoresin				I	-0.3835**	-0.1046	0.2743*	-0.3821**
Gingerol					I	0.1365	-0.2613	0.2276
Starch						I	-0.6495**	0.7710**
Protein							I	-0.5997**
Fibre								I

* *Significant at 5% level.*
** *Significant at 1% level.*

observed generally with increase in maturity levels. This reduction, however is relative and is not caused by actual lowering of oleoresin content but by an increase in the various constituents of ginger such as starch and fibre which form the dry matter. Accumulation of starch and *in vitro* loss of volatiles decrease the essential oil content during ontogenesis of rhizomes. The presence of essential oils in the outer skin established by histochemical examination of ginger peel (Mangalakumari et al., 1984) further confirms the decreasing levels of essential oil during rhizome development. Accumulation of starch and fibre decrease essential oil levels as evidenced by significant negative correlation. During various stages of rhizome development the essential oil cells increase, increasing the oil content (Mathai, 1975). However, the increase is not reflected truely due to the accumulation of other constituents in the rhizome. Eventhough there is a concomitant protein synthesis and degradation in the rhizomes, a negative correlation indicates either *de novo* protein synthesis does not occur or the degradation is much more faster than synthesis.

Dry recovery is negatively correlated with essential oil, oleoresin and proteinaceous compounds during rhizome development. A positive correlation of starch and fibre with dryage further confirms the accumulation of these constituents during maturation.

Essential oil is positively correlated with oleoresin content and negatively correlated with starch. The starch build up during maturation evidently reduces the essential oil levels. The positive correlation of essential oil with oleoresin is well founded as the former is an integral part of the latter (Govindarajan, 1982). Gingerol (an alcohol)—a major pungent constituent counteracting the flavour moeity in essential oil is negatively correlated.

Oleoresin is negatively correlated to gingerol in oleoresin, the principal pungent constituent in ginger. The cultivar with high oleoresin may not have the appropriate pungency and

vice-versa. Fibre which is not extractable by organic solvents is negatively correlated to the oleoresin in ginger. However, the protein is positively correlated to oleoresin latter being solvent extractable.

Starch is negatively correlated to protein. The positive correlation between starch and fibre is well established. A negative correlation between starch and protein and also between protein and fibre, further confirms the above observation.

The present study has indicated that for the yield of rhizomes as well as oils and oleoresin cultivars 'Maran', 'Ernad Chernad', 'Rio de Janeiro', 'Nadia' and 'Karakkal' are superior among 14 cultivars studied.

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