Original Research Article

Exploring Morphological Characteristics, Yield Potential, and Essential Oil Compo*s*ition of *Ocimum sanctum*for its Applications

ABSTRACT

This research focused on the evaluation of 30 accessions of *Ocimum sanctum* for morphological, yield and quality traits. At nursery stage, germination percentages, seedling shoot lengths and seedling root lengths were recorded. Among the accessions. *OS*-22 exhibited the highest germination percentages (82%) Seedling shoot and root length were highest in*Os*-18 and *OS* 21 (35cm and 11cm)respectively. In the main field, the accessions were characterized for qualitative traits viz growth habit, leaf colour and stem colour, The accessions were grouped into two based on growth habit. Based on stem and leafcolour the accessions were grouped into 5 and 4respectively. In case of quantitative traits, plant height was maximum in the accession *OS* 22 (88cm) followed by *OS* 17(75cm). The accessions *OS*-15 and *OS*-22 exhibited more extensive plants spread, while *OS*-21 and *OS*-13 had higher number of primary branches. Accessions *OS*-20 and *O S*-23 recorded more number of leaves (409 and 422) and the accessions *O S*-22 and *OS*-11 recorded highest fresh leaf weight (370.2 &301.67) .Essential oil was distilled from the leaves of Ocimum sanctum accessi*ons*. The oil recovery and oil yield was highest in the accession *OS* 20 (green type) followed by *OS* 22(purple type). Characterization of oil in GCMS revealed that the key component eugenol was highest in accession*Os*-20.

Keywords: Ocimum sanctum,quantitative traits, morphologicalvariation, yield, oil recovery, yield,composition of essential oil.

Comment [y1]: Repetitive keywords

Comment [y2]: This keyword is not appropriate

1. INTRODUCTION

Ocimum sanctum, commonly known as holy basil, comes under the genus Ocimum belongs to the family Lamiaceae and has rich historical use in traditional medicinal systems, particularly in ayurveda. This aromatic plant holds profound significance in various cultures. The therapeutic potential of *Ocimum sanctum* has been recognized for its extensive health benefits. The herb's multifaceted pharmacological actions encompass the ability to counteract physical, chemical, metabolic, and psychological stress. (10) It offers protection against chemical stress like pollutants and heavy metals, as well as physical stressors such as exertion, ischemia, and exposure to extreme conditions.(22) Moreover, it has been shown to positively impact metabolic parameters, including blood glucose, blood pressure, and lipid levels. Its anxiolytic, anti-depressant, and cognitive-enhancing properties contribute to its reputation as an adapt genic herb. It exhibits a broad-spectrum antimicrobial activity. It is rich in diverse metabolites, including essential oils, flavonoids, phenolic

Comment [y3]: the scientific name is not italicized

compounds, and terpenes. (4) The key compound, eugenol, is responsible for its distinct aroma and many of its medicinal effects, including antioxidant, anti-inflammatory, and antimicrobial activities. Other significant metabolites such as caryophyllene, linalool, and ursolic acid further contribute to tulsi's adapt genic and stress-relieving properties. Collectively, these metabolites interact to provide a range of health benefits, encompassing immune system modulation, cardiovascular support, and cognitive enhancement. (7)

Originating from the Indian subcontinent, *Ocimum sanctum* is identifiable by its potent aroma, petite leaves and vibrant green or sometimes purple coloration. Typically, it assumes the form of a compact, bushy annual herb, reaching heights of up to 18 inches. Leaves are in vibrant green, regal purple, or captivating red shades, exhibiting ovate, lanceolate, or oblong shapes and varying in size from small (1-2 cm long) to large (5-10 cm long).(16) Stem enchant with hues of green, purple, or red, while flowers showcase the elegance of white, the softness of pink, or the majesty of purple, with forms ranging from tubular to bell-shaped Among the different variants of *Ocimum sanctum*, "sri tulsi" and "krishna tulsi" stand out, distinguished by the colour of their leaves.Morphological variation in holy basil is thought to be due to a combination of genetic and environmental factors. Hence, the research was conducted to identify a genotype with high yield, oil recovery along with unique morphological traits. (4)

MATERIALS AND METHODS

Seeds of *Ocimum sanctum* accessions were collected from different parts of TamilNadu**.**Seeds were raised in nursery. Seeds germinated after 10 to 14 days of sowing. In the nursery, observation on germination percentage, seedling shoot length and root length were recorded. Seedlings were transplanted to main field at a spacing of 45x 45cm. Regular cultural operations were followed (10) In the main field, both qualitative (plant growth habit, leaf colour, stem colour).Royal Botanical society colour chart was used for screening the germplasm. Quantitative parameters viz. plant height , plant spread ,number of primary branches , number of secondary branches, number of leaves per plant, fresh weight of leaves were recorded. Essential oil was distilled and oil recovery and oil yield were calculated., essential oil of high yielding accessions were analyzed using a Perkin-Elmer (Italy) gas chromatograph (Model 8500) equipped with flame ionization detector (FID), GP-100 printer-plotter and an electronic integrator using BP-1 (SGE, USA) (25 m × 0.5 mm i.e. × 0.25mm film thickness) capillary column coated with polydimethylsiloxane. Nitrogen was used as carrier gas at 10 psi inlet pressure with a flow rate of 0.4 ml/min (linear velocity 14 cm/s). Temperature was programmed from 60 to 220 ◦C at a ramp rate of 5 ◦C/min with a final hold time of 10 min , Identification of individual compounds was achieved by comparing their mass spectra with a relevant database, and quantification was done based on peak areas. The experiment was carried out in triplicate to ensure reproducibility (16)

The data were statistically analyzed by ANOVA applicable to Randomized Block Design. Grouping of genotypes were done based on least significant difference. (13). those accession which are on par with each represent similar morphology.

3. RESULTS AND DISCUSSION

In this study, thirty germplasm accessions of Tulsi (*Ocimum sanctum*) were collected and evaluated for morphological, yield and quality traits. In the nursery, germination percentage (ranged from 5% to 95%). The accession *OS*12 exhibited the highest germination percentage 95%, followed by *OS*20 (75%. However, the accessions *OS*10 and *OS*-3 had

much lower germination rates, at 5% and 10%, respectively. Significant variations was observed for seedling shoot and root length. Shoot length ranged from (8cm to 35 cm). The accession*OS*18 and *OS*16 recorded highest lengths 35cm and 30cm respectively,the accession *OS*10 recorded the lowest shoot length (8cm). Root length ranged from 3cm to 11cm) It was highest in *OS*21 and *OS*22 (11 cm and 10 cm) respectively and lowest in OS7 and *OS*19.Variation was observed for growth habit, stem and leaf colour. Owing to the ease of cr*oss*pollination, morph types, chemo types and genotypes are available in this genus. (13) (1) the accessions were grouped into two based on growth habit viz., erect and spreading. Erect growth habit was observed in 26 accessions (*OS*1,*OS*2,*OS*3,*OS*4,*OS*5,*OS*7,*OS*8,*OS*9,*OS*11,*OS*12,*OS*13,*OS*15,*OS*16,*OS*18,*OS*19,*OS*20 ,*OS*21,*OS*22,*OS*23,*OS*25,*OS*26,*OS*27,*OS*29) and spreading habit was observed in 4 accession (*OS*6,*OS*10,*OS*17,*OS*24).Based on stem colour the accessions were grouped into 5 (table:2) ,Brilliant purple colour was observed in 4 accession (*OS*2,*OS*8,0S15.*OS*22) . Light purple stem colour was observed in 8 accession (*OS*3,*OS*5,*OS*7,*OS*10,*OS*12,*OS*19,*OS*21,*OS*24) were under, Yellowish green stem colour was observed in 6 accession (*OS*4,*OS*13,*OS*16,*OS*26,*OS*28,*OS*30).Deep purple colour of stem was recorded in 7 accessions. Viz., *OS*6, *OS11, OS14, OS17, OS18, OS23, OS27*. Dark green was recorded in 3 number of accessions. (*OS*9, *OS20, OS29*). Based on leaf colour the accessions were grouped into 4 in which accession *OS*1,*OS*4,*OS*5,*OS*7,*OS*8,*OS*10,*OS*12, *OS*15, *OS*16,*OS*21,*OS*23,*OS*24,*OS*26,*OS*27,*OS*29 are grouped under vivid yellowish green colour leaf. Accession *OS*9, *OS11, OS14, OS19, OS20, OS28* were grouped under dark green leaves. Light olivegreen was observed in 5 accession (*OS*2, *OS3, OS6, OS18, and OS30*). Purple colour was observed in 3 accessions (*OS*13, *OS17, and OS22*) (table3). (4) Observations in the main field after 45 days of transplanting revealed significant variations for growth and yield parameters. Plant height (ranged from 15cm to 88cm), the accession *OS*22 recorded the maximum height (88cm, while *OS*8 and *OS*4 had lower height 22.1cm and 23cm, respectively. Plant spread (ranged from 10cm to 62cm)the accessions *OS*15 and *OS*18 recorded highest spreads at 58cm and 59cm, respectively. Number of primary branches ranged from 3 to 22 with *OS*21 having more primary branches (22), followed by *OS*22 with 15 branches. *OS*6 had the fewest primary branches (3). The number of secondary branches ranged from 9 to 76the accession *OS*20 having the more number of secondary branches 72, and *OS*6 having the fewest 9. (5)Further the accession were grouped based on statistical analysis and are arranged in a group based on least significant difference .totally 18 groups were classified and those which have similar characters are arranged in same group and its said to be on par with each other (table: 4) Yield observation like number of leaves per plant also varied significantly, with *OS*20 and *OS*22 having the more number of leaves 422 and 409, respectively, while *OS*9 had the fewest leaves 65. Leaf yield ranged from 115g to 371.5g, with *OS*20 producing the highest yield at 371.5g and *OS*10 producing the lowest yield at 115g.among the accessions*OS*20 recorded more plant height, number of primary branches, secondary branches which in turn resulted in high leaf yield. The genetic improvement of the crop depends m*o*stly on the nature and relative magnitude of genetic variance components concerned with yield and yield related attributes yield.(18) of essential oil recovery % ranged from (0.01 to 1%l) were accession *Os*20, *OS*22 observed 0.9 and 0.85% of essential oil .(8)(11)

Since the yield of *OS*20 and *OS*22 is more due to various factors. This essential oil were subjected to screening of major secondary metabolites like eugenol percentage in *OS*20 is (46%)*OS*22(20%), caryophyllene in *OS*20(10%) and *OS*22(30%), eucalyptol in *OS*20(2%) and *OS*22(0.17%), Methyl eugenol in *OS*20(51.78%) and *OS*22(34%), elemene in *OS*20 (6.8%) and *OS*22(11.6%), and germacrene D in *OS*20(5.3%) and *OS*22(7.2%).(9)(17)The compound alpha-terpinol in *OS*20(5%) and it was absent in *OS*22.chemical compo*s*ition of essential oil mainly depends on soil and climatic condition on the location, growing season and maturity stage however plants subjected to present study were cultivated at the same

location under same soil and climatic conditions and harvested at the same age. (10)therefore variability of essential oil compo*s*ition could be considered as variation between two morphotyes (4)Considering all these observations, it is evident that *Os*20 performed exceptionally well in terms of morphological characteristics, yield, and containing a higher percentage of secondary metabolites, indicating valuable medicinal and pharmacological properties.

Table 1: list of germplasm accessions in *Ocimum sanctum*				
S.NO	Accession number	Place collected	Latitude (^{o} N)	Longitude (^{o} E)
1.	*OS*-1	Tiruchirappali	10.7905	78.7047
2.	*OS*-2	Dindigul	10.3624	77.9695
3.	*OS*-3	Pudukkottai	10.3833	78.8001
4.	*OS*-4	Madurai	9.9252	78.1198
5.	*OS*-5	Salem	11.6643	78.1460
6.	*OS*-6	Erode	11.3410	77.7172
7.	*OS*-7	Dharmapuri	12.1211	78.1582
8.	*OS*-8	Thanjavur	10.7870	79.1378
9.	*OS*-9	Ariyalur	11.1401	79.0786
10.	*OS*-10	Namakal	11.2194	78.1678
11.	*OS*-11	Karur	10.9601	78.0766
12.	*OS*-12	Vellore	12.9165	79.1325
13.	*OS*-13	Thiruvallur	13.1231	79.9120
14.	*OS*-14	Perambalur	11.2342	78.8807
15.	*OS*-15	Viluppuram	11.9401	79.4861
16.	*OS*-16	Theni	10.0079	77.4735
17.	*OS*-17	Musiri	10.9549	78.4439
18.	*OS*-18	kulithalai	10.9426	78.4172
19.	*OS*-19	Neyveli	11.5390	79.4794
20.	*OS*-20	Coimbatore	11.0168	76.9558
21.	*OS*-21	Kanyakumari	8.0844	77.5495
22.	*OS*-22	Tirunelveli	8.7150	77.7656
23.	*OS*-23	Krishnagiri	12.5266	78.2150
24.	*OS*-24	Sivagangai	9.8433	78.4809
25.	*OS*-25	Virudhunagar	9.4218	77.8367
26.	*OS*-26	Ramanathapuram	9.3639	78.8395
27.	*OS*-27	Thoothukudi	8.7642	78.1348
28.	*OS*-28	Thiruvarur	10.7661	79.6344
29.	*OS*-29	Chennai	13.0827	80.2707
30.	*OS*-30	Thuraiyur	11.1519	78.5951

Table :2 Qualitative characterization of *Ocimum sanctum* genotypes			
Accession number	Plant habit	Stem colour	Leaf colour
OS-1	Spreading	Yellowish green	Vivid yellowish green
OS-2	Spreading	Brilliant purple	Light olive green
OS-3	Spreading	Light purple	Light olive green
OS-4	Spreading	Yellowish green	Vivid yellowish green
OS-5	Spreading	Light purple	Vivid yellowish green
OS-6	Erect	Deep purple	Light olive green
OS-7	Spreading	Light purple	Vivid yellowish green
OS-8	Spreading	Brilliant purple	Vivid yellowish green
OS-9	Spreading	Dark green	Dark green
OS-10	Erect	Light purple	Vivid yellowish green
OS-11	Spreading	Deep purple	Dark green
OS-12	Spreading	light purple	Vivid yellowish green
OS-13	Spreading	Yellowish green	Deep purple
OS-14	Erect	Deep purple	Dark green
OS-15	Spreading	Brilliant purple	Vivid yellowish green
OS-16	Spreading	Yellowish green	Vivid yellowish green
OS-17	Erect	Deep purple	Deep purple
OS-18	Spreading	Deep reddish purple	Moderate olive green
OS-19	Spreading	Light purple	Dark green
OS-20	Spreading	Dark green	Light olive green
OS-21	Spreading	Light green	Vivid yellowish green
OS-22	Spreading	Brilliant purple	Deep purple
OS-23	Spreading	Deep purple	Vivid yellowish green
OS-24	Erect	Light purple	Vivid yellowish green
OS-25	Spreading	Deep purple	Light olive green
OS-26	Spreading	Light green	Strong yellowish green
OS-27	Spreading	Deep purple	Brilliant yellow green
OS-28	Erect	Yellowish green	Dark green
OS-29	Spreading	Dark green	Brilliant yellow green
OS-30	Erect	Yellowish green	Light olive

Table 3: morphological parameters of *Ocimum sanctum* genotypes										
Accession name	**Germination %**	**Shoot length (cm)**	**root length(cm)**	**Plant height (cm)**	**Plant spread (cm)**	**No of primary branches**	**No of secondary branches**	**No of leaves**	**Leaf fresh wt. (g)**	**Oil recovery percentage**
OS-1	50.41	18.12	5.00	29.40	24.75	9.00	18.00	75	302.67	0.25
OS-2	29.93	23.30	6.12	39.40	31.23	14.00	31.00	98	210.30	0.20
OS-3	10.10	22.22	4.21	27.36	22.13	9.00	27.00	69	333.00	0.01
OS-4	40.72	19.12	5.52	23.21	20.51	8.00	16.00	88	227.31	0.10
OS-5	19.88	29.52	9.00	56.53	44.55	10.00	25.00	150	215.33	0.50
OS-6	29.88	25.30	4.41	36.42	25.88	3.00	9.00	121	290.71	0.05
OS-7	9.79	15.12	3.33	33.63	22.19	7.00	28.00	89	183.92	0.03
OS-8	19.55	20.30	6.00	22.10	15.43	5.00	10.00	97	222.13	0.10
OS-9*	20.17	17.20	10.12	47.66	41.24	11.00	33.00	160	235.67	0.40
OS-10	4.92	8.15	4.01	15.62	10.22	9.00	18.00	65	115.78	0.02
OS-11	49.69	32.22	7.20	50.55	46.15	10.00	20.00	189	354.67	0.54
OS-12	95.73	27.15	9.33	61.24	51.97	15.00	35.00	210	283.67	0.23
OS-13**	77.60	34.33	5.20	55.12	57.79	9.00	27.00	250	211.25	0.36
OS-14	59.52	29.01	6.12	46.42	50.79	13.00	26.00	291	297.62	0.59
OS-15	64.74	30.25	7.55	57.80	64.27	19.00	29.00	198	369.32	0.45
OS-16	70.01	32.23	8.52	62.43	58.65	20.00	48.00	269	274.67	0.39
OS-17	49.78	25.10	6.30	73.44	33.29	10.00	22.00	150	335.95	0.16
OS-18	83.52	35.31	9.20	78.33	61.30	21.00	33.00	215	367.33	0.62
OS-19	45.16	18.21	3.12	34.24	20.80	8.00	16.00	101	337.15	0.09
OS-20**	**72.58**	33.11	8.33	**57.52**	45.58	19.00	45.00	325	433.70	0.85
OS-21	78.45	24.22	11.01	67.41	51.98	22.00	35.00	269	280.91	0.59
OS-22**	82.92	27.32	9.20	84.30	46.18	15.00	21.00	356	371.52	0.90
OS-23*	90.51	22.10	5.30	73.13	23.26	21.00	36.00	158	282.57	0.31
OS-24	40.18	20.22	6.41	28.62	25.71	11.00	15.00	198	216.01	0.11
OS-25	45.30	16.20	8.20	36.41	20.42	12.00	12.00	120	253.02	0.23
OS-26	71.96	23.30	5.15	38.45	45.81	9.00	15.00	164	314.00	0.25

OS-27	41.58	25.15	6.23	36.34	25.25	10.00	20.00	99	233.66	0.30
OS-28	53.31	22.12	9.00	33.11	14.73	13.0	19.00	222	301.67	0.50
OS-29	28.71	28.30	6.10	46.71	18.13	7.00	31.00	133	235.71	0.22
OS-30	19.28	15.12	4.15	37.30	19.46	11.00	22.00	167	217.50	0.03
mean	48.6000	23.7667	6.4333	45.9967	34.2646	11.6522	31.2333	199.3222	294.6937	0.3260
SEd	1.1412	0.4063	0.1489	2.3492	0.8574	0.2642	0.6086	4.9933	6.1255	0.0063
CD(.05)	2.2847	0.8134	0.2980	4.7029	1.7164	0.5289	1.2184	9.9963	12.2630	0.0127

Table 4: grouping of genotypes based on parameters by statistical analysis

Parameter	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**
Germination %	*OS*12	*OS*23	*OS*13 *OS*18 *OS*22	*OS*22 *OS*18 *OS*21	*OS*20	*OS*16 *OS*26	*OS*15	*OS*14	*OS*28	*OS*11 *OS*11 *OS*17	*OS*19 *OS*25	*OS*19 *OS*27	*OS*4 *OS*24	*OS*2 *OS*6 *OS*29	*OS*5 *OS*8 *OS*9 *OS*30	*OS*3 *OS*7	*OS*10	
Shoot length	*OS*18	*OS*13	*OS*20 *OS*22	*OS*11 *OS*16	*OS*15	*OS*5 *OS*14	*OS*29	*OS*12	*OS*6 *OS*17 *OS*27	*OS*21	*OS*2 *OS*26	*OS*3 *OS*23 *OS*28	*OS*8 *OS*24	*OS*4	*OS*1 *OS*19	*OS*9 *OS*25	*OS*7 *OS*30	*OS*10
Root length	*OS*21	*OS*9 *OS*20	*OS*5 *OS*12 *OS*18 *OS*22 *OS*28	*OS*16 *OS*25	*OS*11 *OS*15	*OS*2 *OS*8 *OS*14 *OS*17 *OS*24 *OS*27 *OS*29	*OS*1 *OS*4 *OS*13 *OS*23 *OS*26	*OS*3 *OS*6 *OS*10 *OS*30	*OS*7 *OS*19									
Plant height	*OS*2	*OS*1	*OS*17	*OS*2	*OS*5	*OS*5	*OS*9	*OS*9	*OS*6	*OS*6	*OS*6	*OS*2	*OS*1	*OS*3	*OS*4	*OS*1		

	2	7 OS18 OS20	OS23 OS20	1	OS12 OS15 OS16	OS13 OS15 OS16	OS11 OS14	OS14 OS29	OS26 OS27 OS30	OS19 OS25 OS27 OS30	OS7 OS19 OS25 OS27 OS28	OS7 OS19 OS25 OS27 OS28	OS2 OS3 OS7 OS24 OS28	OS4	OS8	0		
Plant spread	OS15 OS22	OS16 OS18 OS20	OSs13	OS12 OS14 OS21	OS5 OS11 OS26	OS5 OS11	OS9	OS17	OS2	OS1 OS6 OS24 OS27	OS3 OS7 OS23	OS4 OS19 OS25 OS30	OS29	OS8 OS28	OS10			
No of primary branches	OS21 OS22	OS18 OS23	OS16 OS20	OS15	OS12	OS2	OS14 OS28	OS25	OS9 OS24 OS30	OS5 OS11 OS17 OS27	OS1 OS3 OS10 OS13 OS26	OS4 OS19	OS7 OS29	OS8	OS6			
No of secondary branches	OS20	OS22	OS12 OS21	OS2 OS18 OS23	OS16 OS28	OS15 OS28	OS25	OS9 OS26	OS5 OS17	OS3 OS7 OS13 OS29	OS3 OS13 OS14	OS24 OS30	OS11 OS27	OS1 OS10	OS4 OS19	OS6 OS8		
Leaf fresh weight	OS11	OS13 OS16 OS18 OS20 OS22	OS19	OS13 OS15 OS17 OS19	OS1 OS26	OS1 OS5 OS12 OS28	OS5 OS10 OS21 OS23	OS10 OS14 OS21 OS23	OS25	OS4 OS8 OS27 OS29	OS4 OS7 OS27	OS4 OS7 OS24 OS30	OS2 OS7 OS24 OS30	OS16				
Oil recovery	OS20	OS19	OS14 OS	OS11	OS5	OS28	OS15	OS9	OS16	OS13	OS23	OS1 O	OS12	OS2	OS18	OS4 O	OS6	OS7 O

	OS22		21						*OS17*		*OS27*	*S26*	*OS25* *OS29*			*S8* *OS24*		*S10* *OS30* *OS3*

REFERANCE:

1. Awasthi, P.K. and Dixit, S.C., 2007. Chemical Compositions of *Ocimum sanctum*Shyama and 0cimum sanctum Rama Oils from the Plains of Northern India. *Journal of essential oil bearing plants*, *10*(4), pp.292-296
2. Cohen, M.M., 2014. Tulsi-Ocimum sanctum: An herb for all reasons. *Journal of Ayurveda and integrative medicine*, *5*(4), p.251.
3. Devi, P.U. and Ganasoundari, A., 1995. Radio protective effect of leaf extract of Indian medicinal plant Ocimum sanctum. *Indian Journal of Experimental Biology*, *33*(3), pp.205-208
4. Dharmadasa R.M, Siriwardhane D.A.S, Samarasinghe, 2014. Screening of two ocimum tenuiflorum L. (lamiaceae) morph types for their morphological characters, essential oil composition and fruit fly attractance ability. World journal of agricultural research ; vol. 3, No.1, 1-4
5. Guenther, E., 1960. Determination of physical and chemical properties. *The Essential Oils*, *3*, pp.236-262
6. Hiltunen, R. and Holm, Y., 1999. Essential oil of Ocimum. *Basil: the genus Ocimum*, pp.77-103.
7. Josh, R.K. and Sharma, A.K., 2021. Determination of Seasonal Variation of Volatile Organic Constituents of the Leaves of Traditional Herb *Ocimum sanctum* Linn. *Indian J. Pharm. Sci*, *83*, pp.750-757.
8. Khan A, Ahmad A, Akhtar F, Yousuf S, Xess I, Khan LA, et al. *Ocimum sanctum* essential oil and its active principles exert their antifungal activity by disrupting ergo sterolbiosynthesis and membrane integrity. Res Microbial 2010;161(10):816-23
9. Kovats, E.S., 1965. Gas chromatographic characterization of organic substances in the retention index system. *Adv. Chromatogram.*, *1*, pp.229-247.
10. Kumar, V., Andola, H.C., Lohani, H. and Chauhan, N., 2011. Pharmacological review on *Ocimum sanctum* Linnaeus: a queen of herbs. *J of Pharm Res*, *4*, pp.366-368.
11. Laskar, S. and Majumdar, S.G., 1988. Variation of major constituents of essential oil of the leaves of ocimum-sanctum Linn. *Journal of the Indian chemical society*, *65*(4), pp.301-302.
12. Mahajan N, Rawal S, Verma M, Poddar M, Alok S. A phytopharmacological overview on Ocimum species with special emphasis on Ocimum sanctum. Biomed Prev Nutr 2013;3:185-92
13. Makri, O. and Kintzios, S., 2008. Ocimum sp. (basil): Botany, cultivation, pharmaceutical properties, and biotechnology. *Journal of herbs, spices & medicinal plants*, *13*(3), pp.123-150.
14. Manaharan T, Thirugnanasampandan R, Jayakumar R, Kanthimathi MS, Ramya G, Ramnath MG. Purified essential oil from *Ocimum sanctum* Linn. Triggers the apoptotic mechanism in human breast cancer cells. Pharmacogn Mag 2016;12:S327-31
15. Manikandan P, Murugan RS, Abbas H, Abraham SK, Nagini S. *Ocimum sanctum* Linn. (Holy Basil) ethanolic leaf extract protects against 7, 12-dimethylbenz (a)

Comment [y4]: Reference citations need to be carefully corrected by referring to the journal reference template.

anthracene-induced genotoxicity, oxidative stress, and imbalance in xenobiotic-metabolizing enzymes. J Med Food 2007;10:495-502
16. Mondal S, Mirdha BR, Mahapatra SC. The science behind sacredness of Tulsi (*Ocimum sanctum*Linn.). Indian J PhysiologyPharmacology 2009;53:291-306
17. Ntezurubanza, L., Scheffer, J.J.C. and Svendsen, A.B., 1987. Compo*s*ition of the essential oil of Ocimum gratissimum grown in rwanda1. *Planta medica*, *53*(05), pp.421-423
18. Patel R.P, Kumar .R.R, Singh .R. study of genetic variability pattern and their possibility of exploitation in ocimum germplasm. J industrial crops and products 2015;122
19. Pattanayak P, Behera P, Das D, Panda SK. *Ocimum sanctum*Linn. A reservoir plant for therapeutic applications: An overview. Pharmacogn Rev 2010;4:95-105
20. Salles Trevisan, M.T., Vasconcel*los* Silva, M.G., Pfundstein, B., Spiegelhalder, B. and Owen, R.W., 2006. Characterization of the volatile pattern and antioxidant capacity of essential oils from different species of the genus Ocimum. *Journal of agricultural and food chemistry*, *54*(12), pp.4378-4382
21. Shivananjappa M, Jo*s*h M. Aqueous extract of tulsi (*Ocimum sanctum*) enhances endogenous antioxidant defences of human hepatoma cell line (HepG2). J Herbs Spices Med Plants 2012;18:331-48
22. Zaidi KU, Shah F, Parmar R, Thawani V. Anticandidal synergistic activity of *Ocimum sanctum* and fluconazole of azole resistance strains of clinical isolates. J Mycol Med 2018;28(2):289-93

Formatted: Font: 11 pt, Italic, English (India)