The Pharma Innovation Journal 2023; 12(5): 2705-2712

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(5): 2705-2712

www.thepharmajournal.com
Received: 01-02-2023
Accepted: 04-03-2023

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Potential harvest of secondary metabolites from turmeric (*Curcuma longa* L)

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Abstract
The turmeric (*Curcuma longa* L.) is an important medicinal spice crop. There are several secondary metabolites like Curcumin, Anti-oxidants, Flavonoids, Alkoloids, Poly-phenols, Saponins, Terpenoids, Essential oils and Oleoresins are present in turmeric. The concentration of the various secondary metabolites strongly dependent on the growing conditions, season, various biotic and abiotic stress conditions and growth stage which has impact on the metabolic pathways responsible for the accumulation of the related natural products.The present research was carried out to standardize the growth stage of turmeric for the potential harvest of secondary metabolites. The experiment consisted of six treatments, which includes different stages of harvesting from 4th months after planting to maturity and data was analysed by Completely Randomized Design. The secondary metabolites are increased with advancement of maturity. The maximum potential harvest of secondary metabolites from fingers was found at the maturity of turmeric.

Keywords: Turmeric, secondary metabolites, stages of harvesting, curcumin, essential oils, oleoresin

Introduction
Turmeric (*Curcuma longa* L.) belongs to the family Zingiberaceae (Chattopadhyay *et al.*, 2004) [9]. In various Indian cuisine it uses as a spice. Additionally, it has medicinal benefits (Luthra *et al.*, 2001) [23]. Due to its distinct flavour and its nutritional and therapeutic qualities, it was well-liked even in *Vedic* period. Additionally, it is utilised for cosmetic purposes, religious rituals, and fortunate events (Sanchavat *et al.*, 2012) [35]. Turmeric's vibrant yellow colour is mostly caused by the poly-phenolic pigment curcuminoids (Akram *et al.*, 2010) [3]. Turmeric powder is used in textiles, cosmetics, and as an insect repellent. Due to its health-promoting qualities, turmeric has recently gained recognition as an ideal functional food (Bambirra *et al.*, 2002) [6].

Rheumatoid arthritis, chronic anterior uveitis, conjunctivitis, skin cancer, chicken pox, small pox, wound healing, urinary tract infections, and liver conditions are all treated with turmeric as natural remedies (Dixit *et al.*, 1988) [33]. According to Bundy *et al.* (2004) [8], it is also used to treat dyspeptic symptoms such as loss of appetite, postprandial feelings of fullness, and liver and gallbladder complaints as well as digestive disorders, flatus, jaundice, menstruation problems, and colic. It possesses astringent, choleretic, antibacterial, and anti-inflammatory properties (Mills and Bone, 2000) [24]. The digestive organs are turmeric's primary clinical targets. In the intestine, it can treat conditions like familial adenomatous polyposis, inflammatory bowel disease, and colon cancer (Hanai and Sugimoto, 2009) [16].

Secondary metabolites, a group of bioactive substances having diverse class of compounds like alkaloids, terpenoids, phenols, flavonoids. tannins, saponins, curcumin, essential oil and oleoresins are produced through secondary metabolism in different plants. As the source of medicinal plant, the amount of secondary metabolites content is quite to be concert because it would be affected to the quality of it. The medicinal value of plant lies in these chemical substances that have definite physiological action on human body. The various secondary metabolites have role in ecological functions, including defence mechanisms, by serving antibiotics and by producing pigments. It has also industrial importance including pharmaceuticals, cosmetics and in industrial microbiology includes atropine and antibiotics. Many of them in turmeric there are several secondary metabolites like Curcumin, Antioxidants, Flavonoids, Alkaloids, Polyphenols, Tannins, Saponins, Terpenoids are present. These are synthesized in specific parts of the plant and stored in storage organs (Satyawati and Sharma, 2020) [36].

The research was conducted on Turmeric (*Curcuma longa*) fingers of variety Salem at different growth stages with assumptions that the concentration of the various secondary metabolites strongly dependent on the growing conditions, season, various biotic and abiotic stress conditions and growth stage which has impact on the metabolic pathways responsible for the accumulation of the related natural products.

Materials and Methods

The research experiment on "Potential Harvest of Secondary Metabolites from turmeric" was conducted during the year 2021-22 at the Department of Post- Harvest Management of Medicinal, Aromatic, Plantation, Spices and Forest Crops (MAPSF), Post Graduate Institute of Post-Harvest Technology and Management Killa-Roha, Dist- Raigad, Maharashtra, India. This describes the supplies and tools utilized, the process used to measure the physical and chemical parameters of Turmeric for six months. The fresh turmeric Plant along with rhizomes (Cv. Salem) was obtained from the field of Post Graduate Institute of Post-Harvest Technology and Management Killa-Roha in the month of October 2021 to March 2022, which corresponded to four months after planting.

Physical Parameters

Fresh weight of Rhizomes per plant (g)

The fresh weight of fingers, round rhizomes and rhizomes per plant was computed by randomly selecting five plants. The fresh weight of the five plants fingers, round rhizomes and rhizomes was measured by using weighing balance after cleaning and cutting in small pieces of shoot. The average fresh weight of fingers, round rhizomes and rhizomes per plant was computed.

Dry Matter (%)

This refers to the biomass of the plant without moisture. The turmeric rhizomes was cut into small pieces with help of stainless-steel knife and weighed. The prepared sample of 100g was then kept in hot air oven at 60 ºC temperature till the constant weight was recorded. From this dry matter percentage was calculated.

$$\text{Dry matter}(\%) = \frac{\text{Dry weight of sample}}{\text{Fresh weight of sample}} \times 100$$

Moisture (%)

The initial moisture content of the Turmeric was determined by using the hot air oven method. The fresh plant materials, fingers and mother rhizomes were kept in the trays. The trays were kept in a hot air oven at 45±5 °C. The final weight of plant part, fingers and mother rhizomes was recorded until constant weight. The moisture content was determined by using the following formula (Ranganna, 1986) [32].

$$\text{Moisture content}\ (\%) = \frac{\text{Wm} - \text{Wd}}{\text{Wm}} \times 100$$

Where, Wm= initial weight of sample (g); Wd= weight of dry sample (g).

Chemical Parameters

Curcumin (%)

About 1g of the sample was refluxed with 75 ml acetone for 1 hr after which it was filtered and volume made up to 200 ml. From this further 1ml was taken and volume made up to 100 ml in a standard flask. The UV spectral reading for this solution was recorded at 420 nm. A UV spectrum was recorded for standard curcumin. Percentage curcumin in samples was calculated using the formula: (Geethanjali *et al.*, 2016) [14].

$$\text{Curcumin}(\%) = \text{Ds} \times \frac{\text{As}}{100} \times \text{Ws} \times 1650 \times 100$$

Where,
Ds -dilution volume of the sample;
Ws -weight of the sample taken in grams;
As -absorbance of the sample;
1650 - calculated standard value.

Anti-oxidant activity

Extract Preparation

For the extraction, 20g of each of the samples were weighed out, and 200 ml of methanol was added to each of these 20g samples. They were left to macerate for 24 hr in a shaker at room temperature. Then, the samples were filtered with Whatman paper grade 1. The methanol was removed by evaporation at room temperature in a fume hood. The resulting extracts were stored for later analysis.

Determination of Antioxidant Activity Using the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) Radical Scavenging Method

The antioxidant activity of the plant extracts against DPPH was determined using the method proposed by (Boix *et al.*, 2011) [7]. A methanolic dilution of DPPH 1×10^{-4} M was prepared. Aliquots of 1 ml of each sample in the methanolic extract were collected (at 4 different concentrations: 0.1, 0.5, 1, and 2 mg/ml; two replicates per sample and concentration) and in which 2 ml of methanolic dilution of DPPH added. The mix was kept in the dark at room temperature for 16 min, and absorbance was measured at 517 nm in a UV-30 spectrophotometer. The blank was prepared with the methanolic dilution of DPPH. The results were in milligram equivalents of quercetin per milligram of dry weight. The calibration line was established using the following concentrations of quercetin: 0.001, 0.002, 0.005, 0.01, 0.02, and 0.04 mg/ml.

Flavonoid (%)

The Total Flavonoid content (TFC) of the turmeric shoot as well as fingers was determined by aluminum chloride colorimetric assay (Zhishen *et al.*, 1999) [44]. Briefly, 0.5 ml aliquots of the extract and standard solution (0.01-1.0 mg/ml) of rutin were added with 2 ml of distilled water and subsequently with 0.15 ml of sodium nitrite (5% NaNO2, w/v) solution and mixed. After 6 minutes, 0.15 ml of (10% AlCl3, w/v) solution was added. The solutions were allowed to stand for further 6 min and after that 2 ml of sodium hydroxide (4% NaOH, w/v) solution was added to the mixture. The final volume was adjusted to 5 ml with immediate addition of distilled water, mixed thoroughly and allowed to stand for another 15 min. The absorbance of each mixture was determined at 510 nm against the same mixture but without seed extract as a blank. TFC was determined as mg rutin equivalent per gram of sample with the help of

calibration curve of Rutin. All determinations were performed in triplicate (n=3).

Alkaloid (%)

Total alkaloid content TAC was also quantified by spectrophotometric method (Shamsa *et al.,* 2008) [38]. This method is based on the reaction between alkaloid and bromocresol green (BCG). The plant extract (1 mg/ml) was dissolved in 2 N HCl and then filtered. The pH of phosphate buffer solution was adjusted to neutral with 0.1 N NaOH. 1 ml of this solution was transferred to a separating funnel, and then 5 ml of BCG solution along with 5 ml of phosphate buffer were added. The mixture was shaken and the complex formed was extracted with chloroform by vigorous shaking. The extract was collected in a 10 ml volumetric flask and diluted to volume with chloroform. The absorbance of the complex in chloroform was measured at 470 nm. The whole experiment was conducted in three replicates.

Poly-phenol (%)

Preparation of standard solution

About 10 mg each of gallic acid were accurately weighed into clean and dry volumetric flasks, dissolved in methanol and the volume was made up to 10 ml using the same solvent so as to make the concentration of the solution as 1 mg/ml. Atropine standard solution was taken by dissolving 1 mg pure atropine in 10 ml distilled water.

Preparation of test sample

A stock solution of the test substance was prepared by dissolving 10 mg of dried hydro- methanolic extract in 10 ml methanol to give concentration of 1 mg/ml.

Estimation of total phenol content (TPC)

TPC in the turmeric shoot and fingers was measured spectrophotometrically by Folin–Ciocalteu colorimetric method, using gallic acid as the standard and expressing results as gallic acid equivalent (GAE) per gram of sample according to Ainsworth *et al.* (2007) [1]. Different concentrations (0.01-0.1 mg/ml) of gallic acid were prepared in methanol. Aliquots of 0.5 ml of test sample and each sample of the standard solution were taken, mixed with 2 ml of Folin– Ciocalteu reagent (1:10 in deionized water) and 4 ml of saturated solution of sodium carbonate (7.5% w/v). The tubes were covered with silver foils and incubated at room temperature for 30 minutes with intermittent shaking. The absorbance was taken at 765 nm using methanol as blank. All the samples were analyzed in three replications. The total phenol was determined with the help of standard cure prepared from pure phenolic standard (gallic acid). Folin–Ciocalteu is a very sensitive reagent containing phosphomolybdate and phosphotungstate that form blue-complex in alkaline solution by the reduction of phenols. This blue color was measured spectrophotometrically.

Tannin (%)

Stock solution of 1 mg/ml of tannin acid was prepared by dissolving 100 mg of accurately weighed tannic acid in water. About 1-10 ml aliquots were taken in clear test tube and 0.5 ml of Folin-Denis reagent, 1 ml of sodium carbonate solution were added to each test tube. Each tube was made upto 10 ml with distilled water. All the reagents in each tube were mixed well and kept undisturbed for about 30 min and read at 760 nm against blank reagent. (Polshettiwar *et al.,* 2007) [31].

Saponin (%)

Preparation of crude extract

Saponins were extracted from the turmeric dried plant parts and fingers by following the method of Obadoni and Ochuko (2002) [27]. 2 gm ground powder was dispersed in 100 ml of 20% aqueous ethanol. The suspension was continuously stirred for 4 hr at about 45˚C over water bath. The mixture was filtered and the residue re-extracted with another 200 ml of 20% ethanol. The combined extracts were concentrated by using rotary evaporator in 40˚C to gets 40 ml approximately. The concentrate was transferred into a 250 ml separating funnel and 20 ml of diethyl ether was added and shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The aqueous layer was re- extracted with 30 ml of n-butanol. The n-butanol extracts were washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution was evaporated. After evaporation, the samples were dried in the oven at 40 °C until constant weight.

Determination of total saponin

10 mg crude saponin extracts were dissolved in 5 ml of 50% aqueous methanol. 250 µl of aliquot was transferred to test tubes into which an equal volume of vanillin reagent (8%) was added followed by 72% (v/v) sulphuric acid. The mixture was mixed and placed in a water bath adjusted at 60 °C for 10 min. The tubes were cooled on an ice-cold water bath for 3 to 4 min and absorbance of yellow color reaction mixture was measured at 544 nm against a blank containing 50% aqueous methanol instead of sample extract. The saponin concentrations were calculated from standard curve and expressed as mg diosgenin equivalents (DE) per g of crude extract.

Terpenoid (%)

The terpenoid content was estimated using the protocol by Das *et al.* (2022) [11]. 2g of sample powder was added to screw-capped tubes containing 10 ml of 95% methanol and 200 mg polyvinylpolypyrrolidone (PVPP), sonicated for 15 minutes and incubated in dark for 48 hours at 25°C. The mixtures were sonicated for 15 minutes and incubated in dark for 48 hours at 25 °C. After incubation, the mixtures were filtered and clear filtrate was obtained. 1 ml of each extract was taken in glass tubes and 3 ml chloroform was added to each tube. The tubes were vortexed thoroughly and cooled using ice packs, Conc. sulphuric acid (400 µl) was added to each tube and the tubes were incubated in dark for 4 hours at 25°C. At the end of the incubation period, reddish brown colour appeared at the bottom of the tubes. Supernatant in each reaction tube was carefully decanted and the coloured part was made up to a final volume of 4 ml using 95% methanol. Absorbance of the samples was measured at 538 nm using 95% methanol as blank.

Essential oil (%)

In order to isolate essential oils by hydrodistillation, the turmeric plant material and fresh fingers about 1kg was placed in a distillation flask with sufficient quantity of water and brought to a boil; alternatively, live steam is injected into the plant charge. Due to the influence of hot water and steam, the essential oil is freed from the oil glands in the plant tissue. The vapor mixture of water and oil is condensed by indirect

cooling with water. From the condenser, distillate flows into a separator, where oil separates automatically from the distillate water (Ching *et al.*, 2014) [10]. The essential oil (%) was calculated by following formula.

$$\text{Essential oil}(\%) = \frac{\text{Volume of oil obtained (ml)}}{\text{Weight of sample taken (g)}} \times 100$$

Oleoresin (%)

The plant part and fingers were powdered and passed through 40 mesh sieve to obtain uniform particle size (0.42 mm). Oleoresin was extracted by using various solvents in Soxhlet apparatus until maximum extraction was achieved (~240 min). About 10g of powdered sample were placed in a cavity that is gradually filled with the extracting liquid phase (ethanol) by condensation of vapours from a distillation flask. When the liquid reaches a preset level, a siphon pulls the contents of the cavity back into the distillation flask, thus carrying the extracted analytes into the bulk liquid. This procedure is repeated until virtually complete extraction is achieved. The extract was then concentrated by rotary vacuum evaporator under reduced pressure at 50 °C. The yield of the oleoresins was expressed as percent w/w of dried rhizome powder (Vijayan *et al.*, 2021) [42].

Statistical analysis

To improve experimental and statistical accuracy, the treatments and replications were determined as part of the experiment using a Completely Randomized Design (CRD). The observations were made in replicates of four, and critical differences were calculated to compare the findings of the analysis of various treatments using mean value and ANOVA. Statistical Package for the Social Sciences was used to compile the data, tabulate it, and do analysis (SPSS). Using a completely randomized design, data were analyzed and interpreted, and only significant changes between treatment means at a 5% level of significance allowed for the drawing of valid findings. This was done in line with Panse and Sukhatme (1985) [29] and Amdekar (2014) [4].

Results and Discussion

Effect of different stages of harvesting on physical parameters of turmeric

The results of effect of different stages of harvesting on physical parameters of turmeric were shown in Table No.1. According to the study, it was observed that the significantly maximum moisture of fingers (89.67%) was observed in harvesting at 4th MAP. The significantly maximum fresh weight of fingers, weight of round rhizomes, weight of fingers (539.0g, 56.20g, 482.80g, respectively) and dry matter of fingers (17.37%) was observed in harvesting at 9th MAP.

The fresh weight of fingers was significantly increased along with maturity. The increase in fingers weight coincides with reduction in starch: sugar ratio. Such marked reduction in sugar: starch ratio in leaves indicates that during fingers bulking period, there is more translocation of photosynthates to the fingers. This helps to increase the weight of fingers. The supported result was recorded by (Asafa and Akanbi, 2018) [5] in Ginger**.** The weight of round rhizomes and fingers was significantly increased with increasing the growth stage of turmeric because the accumulation of photosynthates in fingers as well as rhizomes resulting bulking of weight takes place (Lokhande *et al.*, 2013) [22]. Dry matter consists of all its constituents excluding water. Dry matter of rhizomes was significantly increased with increasing the growth stage of turmeric. (Olanipon *et al.*, 2020) [28] reported that dry matter of plant increases because the moisture content decreases along with growth stage terminates towards the maturity. Moisture consists of water content of plants. Moisture content of fingers was significantly decreased with advancement of maturity in turmeric. The moisture of plants decreases along with growth stage because the photosynthetic rate of the plant decreases with increasing the growth rate of plants. Supportive result was recorded by (Hoque *et al.*, 2013) [18] in ginger.

Table 1: Effect of different stages of harvesting on physical parameters of turmeric

MAP	Fresh weight of Rhizome per plant (g)	Weight of round rhizome per plant (g)	Weight of fingers per plant (g)	Dry matter (%)	Moisture (%)
4th	419.0	9.75	409.25	9.33	89.67
5th	438.25	12.25	426.00	10.80	89.20
6th	454.5	13.73	440.78	11.92	88.08
7th	484.25	25.15	459.10	12.02	87.97
8th	502.75	38.33	464.43	15.80	84.20
9th	539.0	56.20	482.80	17.37	82.64

(MAP: Months after Planting)

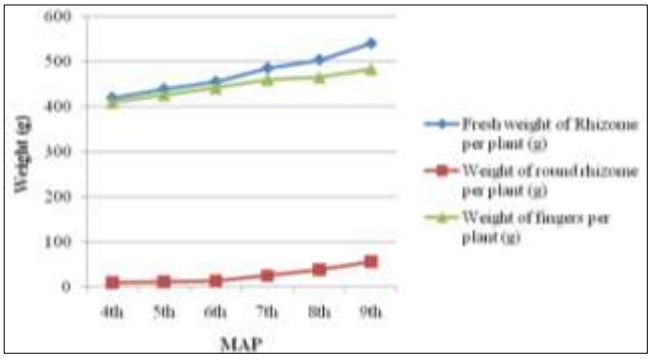

Fig 1: Effect of different stages of harvesting on Fresh weight of Rhizome, Weight of round rhizome and Weight of fingers per plant of turmeric

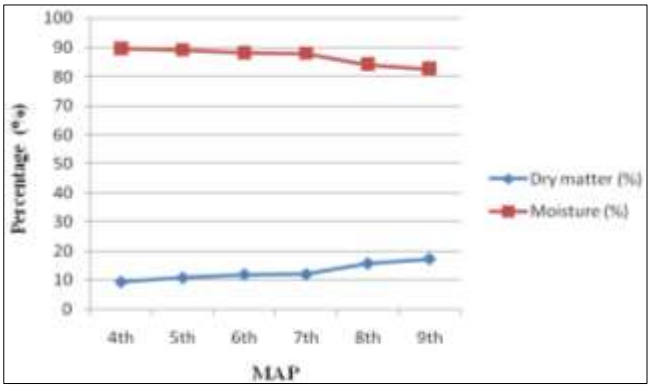

Fig 2: Effect of different stages of harvesting on Dry matter and Moisture of fingers

Effect of different stages of harvesting on secondary metabolites of fingers of turmeric

The results of effect of different stages of harvesting on secondary metabolites of turmeric were shown in Table No. 2. According to the study, it was observed that the significantly maximum curcumin, anti-oxidant activity, flavonoid, alkaloid, poly-phenol, tannin, Saponin, Terpenoid, essential oil and oleoresin of fingers (4.15%, 69.43%, 0.75%, 0.702%, 0.456% 1.03%, 0.428%, 1.013%, 4.15%, 11.30%, respectively) was observed at harvesting at 9th MAP and the significantly lowest mean curcumin (1.91%), anti-oxidant (63.49%), flavonoid (0.54%), alkaloid (0.397%), poly-phenol (0.408%), tannin (0.62%), Saponin (0.294%), Terpenoid (0.780%), essential oil (2.24%) and oleoresin (8.43%) was observed at 4th months after planting. It was noticed from the data the secondary metabolites content of fingers was increased continuously with advancement of maturity in turmeric.

Curcumin is a bright yellow phenolic compound helps in management of oxidation during the entire plant growth. The biosynthesis of curcumin may be takes place in shoot and the fingers are acts as a storage organ for curcumin. The content in fingers was increased continuously with increase growth stage of turmeric. The supportive result was recorded by (Pawar *et al.*, 2014) [30] and (Hazra *et al.*, 2015) [17].

The anti-oxidant in fingers increased continuously with increase in growth stage of turmeric because the redox buffers that interact with numerous cellular components and influence plant growth and development by modulating processes from mitosis and cell elongation to senescence and death. The reduction of photosynthesis rate due to the decreasing trend of water content with advancement of growth stage resulting in increasing the oxidation level. For reduction of oxidation, the anti-oxidant capacity of plant increases with increasing the growth stage. The supportive result was recorded by the (Tanvir *et al.*, 2017) [41] in *Curcuma longa* L.

Flavonoids are usually responsible for the regulating the normal growth and development of the plants. Hakim, (2011) [15] reported that accumulation of free radicals increased with increasing the growth stage that can damage the cells causing illness and aging in plants. Flavonoid of fingers showed increasing trend along with growth stages of turmeric because the falvonoids are responsible for the reducing the activity of free radicals. Supportive result was reported by (Zhu *et al.*, 2010) [45] in *Portulata oleracea*, (Naik and Mishra, 2013) [26] in *Withania somnifera* and *Datura stramonium*, and (Shazia *et al.*, 2016) [39] in seeds of *Abrus precatorius*

Alkaloids are protecting the plants from different types of pathogens and predators and regulate the growth plant. Alkaloids in fingers showed increasing trend along with maturity to regulate the growth and development of the plant. The supportive result was reported by Wang *et al.* (2018) [43] in roots of *Scutellaria bicalensis*, (Ajanal *et al.*, 2012) [2] in Chitrakadivati, (John *et al.*, 2014) [20] in *Justica spp*, and (Dhivya, 2017) [12] in *Micrococca mercurialis.*

The poly-phenols in fingers continuously increasing along with growth stage because Phenylamine ammonia lyase (PAL) catalyses the first committed step in the biosynthesis of phenols and is involved in responses to a plant growth and development. The increase in PAL activity to promote the reactions in Phenylpropanoid pathway (PAL), leading to the increased production of phenols in plants. The supportive result was reported by (Shazia *et al.*, 2016) [39] in seeds of *Abrus precatorius* L and (Soni *et al.*, 2018) [40] in the leaves of *B. arundinacea*.

Tannins plays important role in the physiology and development of the plants. The tannin in fingers increasing with advancement of growth stage. The highest content of tannin was observed at the time of senescence, where the plant reclaims the valuable cellular building blocks that have been deposited in the leaves and fingers due to the accumulation of tannins. The supportive result was recorded by the (KC and Indira, 2016) [21] in leaves of the *Strobilanthes kunthiana*, (Saxena *et al.*, 2013) [37] in *Terminalia chebula*, *Terminalia belerica*, *Terminalia arjuna* and *Saraca indica* whereas (Rangrajan *et al.*, 2021) [33] in *Glycyrrhiza glabra* and *Zingiber officinale.*

The saponin content in fingers it increasing continuously with increase in growth stage of turmeric. Saponin content is dynamic and influenced by the growth stage of the plant because its accumulation enhances the nutrient absorption along with maturity and defending the plant from pest and diseases. The similar result was recorded by Soni *et al.* (2018) [40] in *Phytolacca dodecandra* and *Dioscorea pseudojaponica*. The maximal saponin accumulation has been noted with increasing trend with advancement of maturity and development which has been suggested to protect reproductive organs. The supportive result was reported by (Soni *et al.*, 2018) [40] in leaves of *B. arundinacea.*

Terpenoids plays key role in plant growth and development, physiological processes and they can improve the adaptability of *plants* to the environment. That's why terpenoids in fingers was increasing continuously with increase in growth stage of turmeric. The supported result was reported by the (Jaeger and Cuny, 2016) [19] in the bark of *Eucalyptus globules***,** and (Das *et al.*, 2022) [11] in the tea leaves.

The essential oils are important for the reduction of abiotic stress and it protects themselves from predators, pests and it attracts pollinators. Essential oil in fingers was increasing continuously with increase in growth stage of turmeric because; the increasing maturity of the plant, the cells of plant releases more essential oils. The similar result was recorded by the (Mohebi *et al.* 2017) [25] in *Prangos ferulacea* (L.) and (Ching *et al.*, 2014) [10] in *Curcuma longa.*

Oleoresins in fingers it increased continuously with increase in growth stage of turmeric. Increasing the maturity of the plant enhances the oleoresin production throughout the growth period of plant. The similar result was recorded by (Ravi kiran *et al.*, 2013) [34] in ginger cultivar of Tripura II and Nagaland Nadia.

Table 2: Effect of different stages of harvesting on secondary metabolites of fingers of turmeric

MAP	Curcumin (%)	Anti-oxidant activity	Flavonoid (%)	Alkaloid (%)	Poly-Phenol (%)	Tannin (%)	Saponin (%)	Terpenoid (%)	Essential oil (%)	Oleoresin (%)
4th	1.91	63.49	0.54	0.397	0.408	0.62	0.294	0.780	2.24	8.43
5th	2.02	64.27	0.59	0.414	0.413	0.72	0.299	0.855	2.36	9.18
6th	2.09	65.84	0.65	0.484	0.418	0.82	0.305	0.893	2.44	9.66
7th	2.83	66.34	0.69	0.543	0.420	0.88	0.355	0.908	2.51	10.36
8th	3.26	67.58	0.73	0.643	0.439	0.94	0.414	0.954	3.70	10.75
9th	4.15	69.43	0.75	0.702	0.456	1.03	0.428	1.013	4.15	11.30

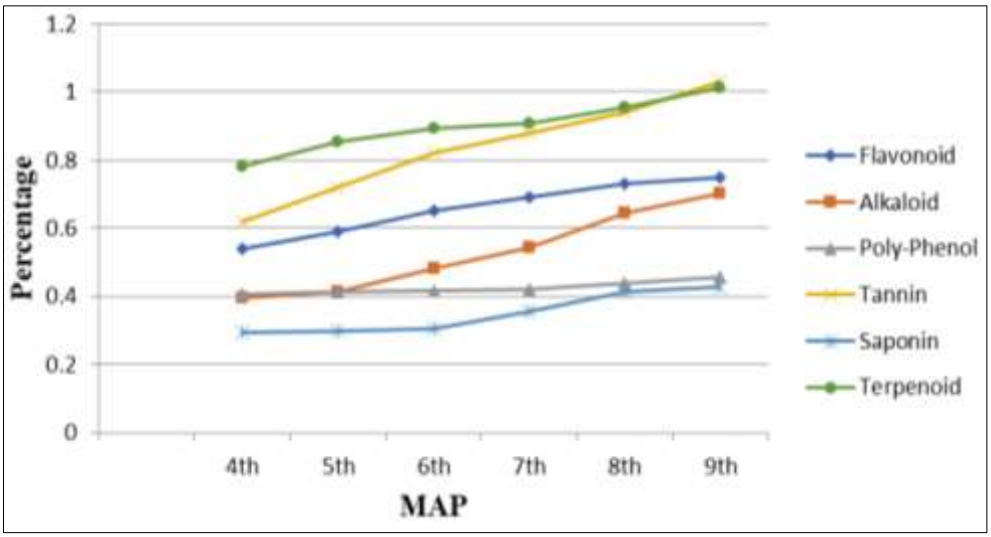

Fig 3: Effect of different stages of harvesting on flavonoid, alkaloid, poly-phenol, tannin, saponin and terpenoid content of fingers per plant of turmeric

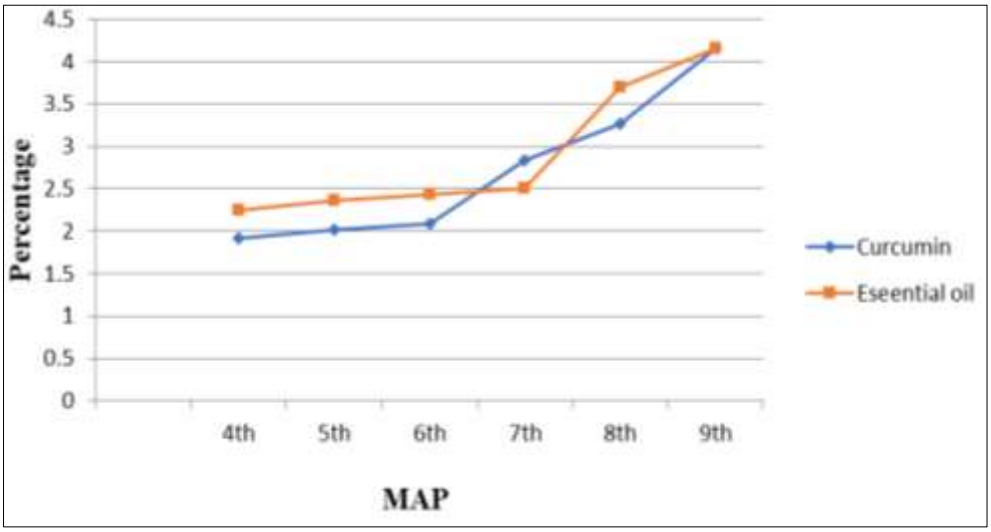

Fig 4: Effect of different stages of harvesting on flavonoid, alkaloid, poly-phenol, tannin, saponin and terpenoid content of fingers per plant of turmeric

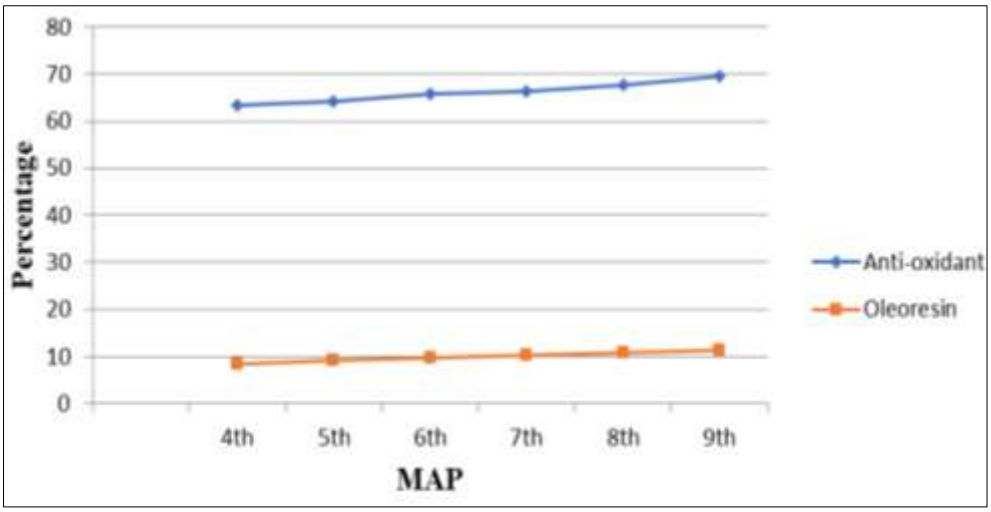

Fig 5: Effect of different stages of harvesting on anti-oxidant and oleoresin content of fingers per plant of turmeric

Conclusion

The turmeric fingers contains maximum amount of secondary metabolites. These are synthesized by the shoots or leaves and stored in stored organs like fingers. Thus for the maximum potential harvest of secondary metabolites from fingers, the crop should be harvested at horticultural maturity.

Acknowledgment
We are thankful for the requisite facility provided by the Post Graduate Institute of Post-Harvest Technology and Management Killa-Roha.

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