

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

4,800

Open access books available

122,000

International authors and editors

135M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.

For more information visit www.intechopen.com



Cultivation of Ginger in Sikkim under an Organic System

Vijayan A.K., B.A. Gudade, Ashutosh Gautam, T.N. Deka, S.S. Bora, K. Dhanapal and A.B. Remashree

Abstract

Ginger is grown extensively throughout India due to its high value and ginger is used for wide range of purposes like in confectionery, traditional medicine for stomach ache, food additives and pickles. The major ginger-producing states include Kerala, Assam, Gujarat, Orissa, Sikkim, Meghalaya, Arunachal Pradesh and Mizoram. It is one of the main cash crops in Himalayan state of Sikkim. In Northeast India, especially in Sikkim, ginger serves as a source of income for small and marginal farmers. It is cultivated in a varying degree of altitude, but the elevation of 1500 above msl is found to be more suitable. Ginger is a tropical plant, and warm, humid climate is the most ideal for ginger cultivation; it grows best in rich soil and shady places. Sikkim has its own indigenous cultivars of ginger, and the prominent varieties that are being cultivated in Sikkim are Bhaise, Gorubathane, Majhaule, Tange, Patle and Jorethang. November to January after 8–9 months of sowing is the optimum time for harvesting ginger; however, this follows the market demand dynamics in Sikkim. Under organic conditions, farmers normally get a yield of 90–100 q/ha depending on ginger cultivation practices. Progressive farmers by adopting improved method of ginger cultivation get on an average of Rs. 150,000 per hectare (benefit-cost ratio varied from 3.50 to 3.80).

Keywords: *Zingiber officinale* Rosc, Sikkim, organic system

1. Introduction

Ginger botanically known as *Zingiber officinale* Rosc. is a crop of family Zingiberaceae and grown extensively throughout India. It is a perennial herbaceous flowering plant which grows annual pseudo-stems whose rhizome, ginger root or ginger is widely used as a spice and a folk medicine. In India, ginger is used for wide ranges of purposes like confectionery, traditional medicine for stomach ache, food additives, pickles, etc. Traditionally, the rhizome is gathered when the stalk withers; it is immediately scalded or washed and scraped, to kill it and prevent sprouting. In China it is used as a typical traditional medicine that has been widely used for the treatment of indigestion, sore throats, rheumatism and hypertension [1–4].

Ginger has been demonstrated to have various pharmacological activities, such as antiemetic, antiulcer, anti-inflammatory, antioxidant, antiplatelet and anticancer activities [5–8].

The major ginger-producing states include Kerala, Assam, Gujarat, Orissa, Sikkim, Meghalaya, Arunachal Pradesh and Mizoram. Ginger is grown as an

intercrop in coconut and areca nut plantations in the states of Kerala, Meghalaya, Orissa and West Bengal and to some extent in Karnataka as well as pure crop in the states of Andhra Pradesh and Tamil Nadu [9, 10].

It is one of the main cash crops in Himalayan state of Sikkim and locally known as “Adua”, and its cultivation in the state can be traced in ancestral farming in ancient time. Limboos, Phedamngmas, Rai and Bijuwas used ginger in religious practices as well as medicinal application for different purposes. In Northeast India especially in Sikkim, ginger serves as a source of income for small and marginal farmers. It is cultivated in a varying degree of altitude, but an elevation of 1500 above msl is found to be more suitable. The areas which cover major area under ginger cultivation in the state are Tharpu, Malbansey, Gyalshing, Mangalbaria belt, Chakung, Chumbung and Zoom in the West district; Rhenock, Rongli, Rorathang, Pakyong, Pachekhani, Pandam, Khamdong, Sirwani, Sang and Namziism in the East district; Turuk, Sumguk, Ratepani, Namthang, Melli Dara, Maniram, Namchi, Temi Tarku and Bermiok in the South district; and small pockets of Dzongu and Mangan area of the North district.

2. Crop botany

Ginger is an herbaceous perennial crop belonging to the family Zingiberaceae. It is cultivated for its rhizome which is a modified system. It is an aromatic herb with an underground rhizome and an erect stem, up to 75 cm in height. The leaves are green, simple, alternate, sheathing at the base, sessile, acuminate at the apex, glabrous, 15–20 cm long, narrow and linear-lanceolate with prominent midrib and parallel venation. Inflorescence is a spike on a distinct scape; flowers are densely arranged, bisexual and irregular, each subtended by a persistent scarious bract.

Calyx tubular shortly 3-lobed; corolla bilabiate, tubular below, yellow with purplish spots stamens three in one whorl, one of which is perfect and the other two united to form a labellum; ovary of three carpels, syncarpous, 3-celled, inferior; ovules many on axile placentas; style filiform, lying in a groove of the anther; stigma subglobose, filament of perfect stamen short, anther cells contiguous, connective produced into a beak. Flowering in Sikkim is a common phenomenon, but it flowers only in a specific climatic conditions. Ginger produces clusters of white and pink flower buds that bloom into yellow flowers. It is a perennial reed-like plant with annual leafy stems, about a metre (3–4 feet) tall.

3. Uses

Ginger has a wide range of traditional and present-day uses in Indian households, and Sikkim is not an exception too. In Sikkim conditions, ginger is marketed as fresh and used mostly in salad, tea blends, sauces and additives as well as a sole constituent of curry and pickles, confectionery, curry powder, ginger chocolates and candies and for beverage purposes like ginger cordial, ginger cocktail, ginger tonic, ginger brandy, ginger wine, ginger beer, etc. It has many medical values and is used as carminative and stimulant for gastritis, dyspepsia and flatulence and a remedy for bee bites, etc. Ginger contains a variety of oleoresin and volatile oils which are low-volume high-cost products for marketing and fetches high monetary returns.

4. Climate and varieties

Ginger is a tropical plant, and warm, humid climate is the most ideal for ginger cultivation; it grows best in rich soil and shady places. Ginger can be grown both

under rainfed and irrigated conditions. The well-distributed rain during the growing season, i.e. from April to October, is ideal for its cultivation. This is the reason that this crop is grown from 300 to 1500 m above msl in Sikkim, where the temperature remains higher during the growing period. It is partially a shade-loving crop and can be grown in semi-shaded condition. Sikkim has its own indigenous cultivars of ginger, and the prominent varieties which are being cultivated in Sikkim are Bhaise, Gorubathane, Majhaule, Tange, Patle and Jorethang.

5. Existing practices of ginger cultivation

It is usually cultivated vegetatively, meaning the pieces of rhizome are planted in the soil and each sprouts to form a new plant. Modern micropropagation is also being used where new plants are cloned from cells taken from a single plant [11]. The propagation through rhizome cuttings includes small bits of rhizome; each containing a bud is planted in holes or trenches 10–15 cm deep and about 30 cm apart during the months from March to May. The plants produce aerial shoots which are dried after flowering and fruiting in a span of about 8–10 months. Though ginger requires ample rainfall, there should not be any waterlogging at any time; otherwise, it may result in rotting.

In Jamaican practice, rhizomes are dug up and washed with water to remove adhered soil and dirt. Rhizomes are then peeled and washed in clean water often containing lime juice. The cleaned materials are sun-dried for 120–140 hrs; proper care should be taken that there should not be any damping or mouldy condition during the process of drying. They are then bleached by washing and again dried for 2 days.

In traditional Indian practice, the rhizome is peeled on the flat sides only followed by treatment with boiling water and sun-drying. Sometimes the dug-up rhizomes are washed in clear water and peeled or scrapped and then coated with carbonate or sulphate of lime. This protects the rhizomes from insect attack. The skin gathered from such peeled rhizomes is often distilled and oil is obtained.

Here in Sikkim, the most common practice of ginger cultivation is growing in terrace as well as in hill slopes. Ginger prefers light-textured soil which is rich in organic matter; this results in good yield of crop, and rhizomes have a better size and appearance and texture as well. Heavy soil with poor drainage should be avoided since it causes waterlogging and physiological drought.

6. Land preparation

Ginger needs fine bed preparation before sowing which is done by 2–3 ploughings or is dug 2–3 times. The sizes of the beds are variable according to available land size, but a width of 75–100 cm and height of about 15–20 cm with 30–45 cm are recommended for sowing. Raised beds should have a gentle outward slope to tackle the problem of avoid.

7. Seed selection and treatment and sowing

Healthy and disease-free planting material is the first requirement of any crop, and the same is followed in ginger too. When the crop is 6–8 months old and still green, the clumps are marked in the field. The seed rhizomes are treated with a mixture of 10% solution of bioagents, viz. *Pseudomonas* and *Bacillus*, for 30 min and dried under shade before storage or before sowing. In order to obtain good germination, the seed rhizomes are to be stored properly in pits under shade.

In Sikkim the last week of February to March is the most optimum timing of sowing; however, in most of the location, it is continued till April.

8. Sowing and spacing

Generally line sowing in shallow pits on raised beds with a row-to-row distance of 30–45 cm and plant to plant 15–20 cm is followed in ginger. Where ginger is sown as intercrop like with maize, then it is sown in 2–4 lines with spacing maintained at 60–90 cm, and maize is sown in between the rows of ginger. Usually seed rhizomes are broken into small pieces of 5–8 cm in length, weighing 30–60 quintal/ha, or even more seed is sown; however, many farmers sow full rhizome without breaking.

9. Nutrition management

Application of 20–40 tonnes of cow dung or compost in soil is recommended before sowing though heavy manuring (up to 50 tonnes/ha) in ginger field is a common practice. Farmers in Sikkim do not use any fertilizer in ginger field citing their observation that the use of fertilizers enhances rotting (soft rot), while others use dolomite which reduces rotting.

10. Mulching

To tackle the problem of post-sowing water stress, beds are covered with dry leaves, straw or other plant residues. Covering the bed with green leaves and twigs of Chillaune (*Schima wallichii*) or other forest plants is a common practice followed by some farmers. Based on the availability, mulch may vary from 5 to 20 tonnes/ha on a dry basis. Mulching not only helps in moisture management, but it also gives heat to the beds, enhances germination, reduces weeds, protects young emerging plants with heavy rain and hailstorms and minimizes soil erosion. In post-decomposition phase, mulch turns into a source of nutrients to the soil and copes up the need of growing plants.

11. Weeding and earthling up

Heavy rain is a major issue in ginger cultivation in Sikkim; it not only causes weed problem but waterlogging and soil runoff and favours outbreak of insect pest as well. To tackle the weed problem, 2–4 hand weeding is recommended as per the growth stages of the crop and weed. Weeding is followed by earthling up to cover the exposed rhizome.

12. Removal of mother rhizome (Mau)

Mother rhizome locally known as *Mau* is dug up by the month of May–June, leaving the sprouted bit of rhizome in the soil. This is done to maintain proper space to the developing rhizome and earn extra income during off season. In Sikkim, farmers get almost equal quantity, whatsoever sown, though it is of inferior quality, but being an off-season product, it fetches good market price.

13. Intercropping and crop rotation

Though ginger is grown as a sole crop in majority, it is not an uncommon thing to grow it with soybean, French bean and cowpea as intercrop. In order to provide better shade and utilize the vacant space up to maximum, farmers cultivate ginger in citrus and guava orchards as well.

Crop rotation is a common practice seen in Sikkim, and farmers tend not to cultivate ginger continuously year after year. Based on the size and suitability of the land holdings, sometimes crop rotation is followed for more than 2–4 years. The main reason of adopting crop rotation as cited by the farmers is the incidence of rhizome rot which can be minimized.

14. Issues and constraints in better production

Sikkim is a state with highly undulating topography and difficult area of reach. Farmers have small or marginal land holding which limits their choice of crops and adoption of improved technology. The steep slope and difficult terrain are other permanent issues which cause problem in field preparation, transportation of inputs and carrying of harvest to the house and markets. Winter is a dry spell in most of the areas and limits the moisture availability to crop which results in the reduced yield level, whereas during the rainy season, excess rainfall is conducive to the luxuriant growth of many weed floras which not only compete with the main crop but act as an alternate and collateral host for many insect pest and diseases. Poor infrastructural facilities and transportation issues force farmers to sell their produce at lower rates in local markets. The farmers of Sikkim are sound neither technically nor financially; this restricts the use of adequate fertilizer, improved varieties, pesticides and other inputs and recent technologies.

Sikkim is characterized by high annual rainfall (more than 2500 mm), high humidity and rather a mild and favourable range of temperature (13–23°C), most of the time cloudy, less duration of bright sunshine and great variation in altitude; a wide variety of floras and faunas give an opportunity for the survival, perpetuation and building up of many plant pathogens. The continuous rain from June–September reduces the labour efficiency drastically. It affects weeding, spraying and other agricultural operations. Sometimes severe hailstorms in April–May damage the early sown crop badly.

Due to the above reasons, this crop suffers with a number of insect pests and diseases in the field as well as in the storage causing heavy yield loss every year. Lack of knowledge, the use of poor quality seed, no crop rotation, extraction of mother rhizomes and poor storage condition are some other production constraints.

15. Insect pests

Ginger has a wide range of insects and pests affecting the crop and loss in yield. The major insect pest and their management are discussed below.

15.1 Stem borer/shoot borer (*Conogethes punctiferalis* Guen.)

This is one of the most serious pests in ginger; the infestation generally starts in June and continues till October. This pest is found more severe in Central Pendam, Sajong, Bhurung and Pachekhiani areas. Shoot borer's caterpillar damages the plant by boring central shoot of the plants which in due course of time turn yellow and get dry.

Its intensity was very high (15–33%) in Zoom, Chakung, Chumbung and Malbasey areas in West Sikkim. Rouging, removing and burning the affected shoots and maintaining proper phytosanitation are the primary management strategies for this pest. Spraying of NKAE 5.0% solution or 3% neem oil at 3 ml/l of water or 0.3% of *Bacillus thuringiensis* product in an interval of 2–3 weeks during June–October is found to be effective. The process of spraying should be initiated as soon as the symptoms appear on pseudo-stem or leaves without any delay. Pruning and rouging of freshly infested pseudo-stems at fortnight intervals along with spraying are effective against the pest.

15.2 White grub (*Holotrichia* spp.)

White grub is another major pest in ginger which damages the crop by feeding upon the feeder roots and the rhizomes. The infestation of this pest is well recorded in the state and was found localized. During the August–September months of 1989, white grub was recorded an epidemic form in Bikmat village (Namthang area) of South District. The intensity of infestation was so severe that it affected 80–90% of ginger crop and forced the farmers to go for premature harvesting. The control measures include collection of adult beetles, and killing during their breeding season manages this pest as well as removal and destruction of alternate hosts like Nebhara, Gagun, Utis, Dudhilo, Bar, etc., to avoid resurrection in adult stage of pest.

16. Diseases

Though there has been the considerable number of diseases in ginger, major diseases in Sikkim conditions are classified as (i) root and rhizome diseases, (ii) foliar diseases and (iii) storage diseases and discussed below in detail. Root and rhizome diseases are very serious as they cause heavy yield loss. Among these, soft rot, yellow/dry rot, bacterial wilt and nematode diseases are the most important.

16.1 Root and rhizome diseases

16.1.1 Soft root

Soft root is one of the most devastating diseases of ginger caused by *Pythium* sp. And among them *Pythium aphanidermatum* is the most common; this disease may account the yield loss up to 50%.

Symptoms of this disease include yellowing of the tips of lower leaves which gradually spreads down to the leaf blade and leaf sheath along the margin. Initially leaves show yellowing only in the marginal area, and the middle portion remains green but later on the yellowing spreads to the whole leaf followed by drooping, withering and drying. The collar region of the pseudo-stem turns pale brown and appears as water soaked. The infected shoot can be easily pulled out from the soil; the infection from the collar spreads to the rhizome gradually. There are two stages of the disease: (a) seed rhizome stage in which the shoots arising from such rhizomes show the damping-off symptom in the seedling stage and (b) post-germination stage where the fully grown pseudo-stem withers and dies.

Soft root of ginger spreads either through infected planting material or the spores present in the soil, and rainwater assists the infestation in the second case from one field to another. Treating the seed rhizomes with 10% solution of mixture of *Pseudomonas* and *Bacillus* for 30 min followed by drying in shade before storage and the same treatment before sowing reduces the incidence of the disease.

16.1.2 Rhizome rot/dry rot/*Fusarium* wilt

Rhizome rot/dry rot/*Fusarium* wilt caused by *Fusarium oxysporum* is a common disease of ginger particularly in South Sikkim.

The disease can be identified by peculiar symptom yellowing which first appears on the lower leaves of young plants followed by yellowing involves whole of the leaf and wilting in The pseudo-stem is very weak and wilted and can be easily pulled out from the mother rhizome. The underground symptoms of the disease appear on the rhizomes and roots, showing creamy brown discoloration of vascular system. As a result of this, rotting of roots takes place and rhizome formation ceases.

16.1.3 Bacterial wilt

Bacterial wilt caused by *Pseudomonas solanacearum* was first observed in Sikkim in Rhenock and adjoining areas in an epiphytotic form causing yield loss. Water-soaked linear streaks/lesions or patches on the collar region of the pseudo-stems followed by yellowish to bronze coloration of the margin of the lower most leaf which gradually progress upwards are common symptoms of the disease. In due course of time, the leaves become flaccid showing typical wilting, yellow bronze-coloured margins and drooping. The affected pseudo-stems and rhizomes at the advanced stage of infection are slimy to touch with a varying degree of tissue disintegration, and milky bacterial exudates ooze when pressed gently. Symptoms of this disease mimics as of *Pythium*; however, when a small piece of infected rhizome is kept in water, it gives off turbid bacterial ooze, a symptom distinctly different from that of *Pythium*-infected rhizomes. *P. solanacearum*, the casual organism of bacterial wilt, grows best at 34°C.

It is difficult to manage the root and rhizome disease of ginger due to seed- and soil-borne nature; hence, intergraded disease management strategies are advised to minimize the intensity of the disease. In cultural practices, such as selection of well-drained soils for planting, avoidance of the stagnation of water, selection of disease-free planting material, removal of affected clumps and drenching of the affected and surrounding beds with 0.3% COC, drenching with 10% *Pseudomonas* and *Bacillus* helps to reduce the disease infestation. Along with the above practices, treatment of seed rhizomes with 1% Bordeaux mixture or 0.2% copper oxychloride can also be done.

16.2 Foliar disease

16.2.1 Leaf blight/leaf spot

Leaf blight/leaf spot of ginger is caused by *Leptosphaeria zingiberis* and can be identified by initial symptoms of spindle-shaped 5- to 10-mm-long yellow spots. Gradually the spots increase in size and become necrotic with ashy appearance in the centre and distinct yellow diffuse margin. The presence of light brown colour in between the central necrotic zone and outer yellow margin is another trait of the disease. Under high humid conditions, two or more spots coalesced and resulted in brightening of the affected leaves, and black dot-like minute fruiting bodies are noticed in the central necrotic portion of the affected leaves.

Spraying with 10% *Bacillus/Pseudomonas* solution or 0.2% COC at an interval of 10–15 days helps to reduce the disease intensity.

16.2.2 *Phyllosticta* leaf spot

Phyllosticta leaf spot is caused by *Phyllosticta zingiberi*, and peculiar symptoms are appearance of 1- to 10-mm small oval to elongated spots on leaves. The spots are

usually isolated but may coalesce forming big lesions causing extensive discoloration and desiccation. A mature spot is white and papery at the centre and has dark brown margin with a yellowish halo surrounding it.

Control measure for *Phyllosticta* leaf spot is as the same as in the case of leaf blight.

16.3 Storage diseases

Climatic conditions in Sikkim are highly favourable for fungal disease of ginger in storage conditions causing deterioration and subsequent heavy loss. In storage, *Fusarium* spp., *Botryodiplodia theobromae*, *Memnoniella echinata* and *Stachybotrys atra* are found to be primary fungi responsible for diseases.

To minimize or avoid disease infestation in storage, the temperature and relative humidity should be maintained at 13°C and 67%, respectively. Prestorage treatment of rhizome with 10% solution of mixture of *Pseudomonas* and *Bacillus* for 30 min dipping and there after drying in shade is helpful to reduce the incidence of the disease.

17. Recommendations for better production

- Procure ginger seed from the areas/fields where there was no disease or very less disease.
- Use always healthy (disease-free) rhizomes for sowing.
- Use always well-rotten cow dung/compost in the field.
- Follow crop rotation at least for 3–4 years.
- Avoid waterlogging in ginger field.
- Try to avoid removal of mother rhizomes as it enhances disease intensity.
- Keep the field weed-free.
- After every weeding, earthing up should be done. No rhizome should be exposed to sunshine.
- Suitable intercrop, viz. soybean, French bean and cowpea, may be practised for getting higher and higher yield.
- Take appropriate measures for disease and pest management.
- Select fully mature seed rhizomes for storage free from insect and disease attack.
- For the overall management of the insect pests and disease, in this hilly state, one should adopt as a rule integrated pest management (IPM) strategies. Sikkim is declared as an organic state and hence application of chemical to be avoided. We should encourage natural biocontrol agent and other cultural practices for the management of the pest and diseases.

- Departments/agencies should arrange regular training for the field functionaries and farmers for the adoption of improved methods of ginger cultivation and plant protection measures.
- Local varieties are very promising, but their regular cultivation may pose some degeneration problem therefore. Selection of healthy and bold rhizomes should be regular practices.

18. Harvesting and yield

November to January after 8–9 months of sowing is the optimum time of harvesting the ginger; however, this follows the market demand dynamics in Sikkim. Yellowing of green leafy pseudo-stem turns followed by withering is maturity index for ginger, and crop is said to be ready for harvest. Mature rhizomes are dug carefully with a spade taking care not to bruise or break the fingers and can be stored at 13°C temperature and 67% relative humidity for the period of 10 months. Farmers normally get a yield 90–100 q/ha depending on ginger cultivation practices.

19. Processing

Ginger is extremely versatile and has a wide range of uses right from food additives to medicinal. Ginger is processed to give ginger oil, oleoresins, candy, preserves, ginger powder, starch from sport ginger, ginger brandy wine, beer and medicinal beverages and treatment for dehydration. Some of the ginger products are drained ginger, syrup ginger, dusted ginger, crystallized ginger, brined ginger, pickled ginger, dried ginger, etc. Ginger can be used in a myriad of food products ranging from bakery items to confectionary, beverages, marinades and sources, candies, ice cream and desserts, jams and spreads, prepared foods, health foils and nutraceuticals.

20. Storage

Farmers store ginger rhizomes in their houses either on floor or racks made of bamboo, while a few keep in pits and cover with paddy straw, dry leaves and soil. The bottom of the pits is covered with sand and paddy straw, and a roof is provided over it. Normally healthy and bold rhizomes are selected for storage, and frequently diseased rhizomes are sorted out to avoid spread of diseases.

21. Marketing

There is a ready market for fresh ginger in Sikkim. Before bringing the ginger to the market, farmers clean the ginger after harvest by removing adhering soil particles. Sorting is done at the trader's level to remove light, diseased, cut or deformed ginger rhizomes. In this process 8–10% produce is discarded. About 30% produce is sold in the village itself to the local merchants or commission agents. The remaining produce is taken to the market for sale to commission agents/wholesalers. The main marketing centre in Sikkim are Gangtok, Pakyong, Singtam

and Rangpo in the East district; Namchi, Jorethang and Melli in the South district; Mangan and Dikchu in the North district; and Gyalshing, Rishi, Legship and Nayabazar in the West district.

22. Economic returns

Progressive farmers by adopting improved method of ginger cultivation get on an average of Rs. 150,000 per hectare (benefit-cost ratio varied from 3.50 to 3.80) provided the crop is not damaged by rhizome rot or any other devastating pest.

Author details

Vijayan A.K.^{1*}, B.A. Gudade^{2*}, Ashutosh Gautam¹, T.N. Deka², S.S. Bora², K. Dhanapal¹ and A.B. Remashree¹

1 Indian Cardamom Research Institute, Idukki, Kerala, India

2 Indian Cardamom Research Institute, Gangtok, Sikkim, India

*Address all correspondence to: drvijayanicri@gmail.com and bgudade@gmail.com

IntechOpen

© 2020 The Author(s). Licensee IntechOpen. This chapter is distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/3.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited. 

References

- [1] Ali BH, Blunden G, Tanira MO. Some phytochemical, pharmacological and toxicological properties of ginger (*Zingiber officinale* Roscoe): A review of recent research. *Food and Chemical Toxicology*. 2008;**46**:409-420
- [2] Dedov VN, Tran VH, Duke CC, Connor M, Christie MJ, Mandadi S. Gingerols: A novel class of vanilloid receptor (VR1) agonists. *British Journal of Pharmacology*. 2002;**137**:793-798
- [3] Hu WY, Zhang RP, Tang LP, Liu G. Research progress in the chemical constituents and pharmacology of ginger. *Chinese Journal Ethnobiol Ethnomed Pharmacology*. 2008;**9**:10-14
- [4] Jiang H, Xie Z, Koo HJ, McLaughlin SP, Timmermann BN, Gang DR. Metabolic profiling and phylogenetic analysis of medicinal *Zingiber* species: Tools for authentication of ginger (*Zingiber officinale* Rosc). *Phytochemistry*. 2006;**67**:232-244
- [5] Bhandari U, Sharma JN, Zafar R. The protective action of ethanolic ginger (*Zingiber officinale*) extract in cholesterol fed rabbits. *Journal of Ethnopharmacology*. 1998;**61**:167-171
- [6] Fuhrman B, Rosenbat M, Hayek T, Coleman R, Aviram M. Ginger extract consumption reduces plasma cholesterol, inhibits LDL oxidation and attenuates development of atherosclerosis in atherosclerotic, apolipoprotein E-deficient mice. *The Journal of Nutrition*. 2000;**130**:124-131
- [7] Nicoll R, Henein MY. Ginger (*Zingiber officinale* roscoe): A hot remedy for cardiovascular disease. *International Journal of Cardiology*. 2009;**131**:408-409
- [8] Shukla Y, Singh M. Cancer preventive properties of ginger: A brief review. *Food and Chemical Toxicology*. 2007;**45**:683-690
- [9] Babu MS, Kumar BP, Swami DV, Krishna KU, Emmanuel N. Performance of ginger (*Zingiber officinale* Rosc) varieties under shade net condition of costal Andhra Pradesh. *International Journal of Current Microbiology and Applied Sciences*. 2017;**6**(7):494-498
- [10] Chhetri P, Gudade BA. Organic production of ginger: A prominent sub-Himalayan spice. *Popular Kheti*. 2013;**1**(4):207-210
- [11] Bhatt N, Waly MI, Musthafa ME, Ali A. *Ginger: A Functional Herb*. New York, USA: Nova Science Publishers, Inc.; 2013. ISBN-978-1