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# Breeding For Quality Improvement In Major Spice Crops: A Review

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**Abstract**

Spices, the products of plant origin used for seasoning food to add flavor and aroma. It also alters the taste of the food generally giving pungency. India is well known as a land of spices from times immemorial. Export of spices and spice products from India, registered a rise of nine percent in volume and eight percent in value compared to previous year. Quality traits *viz.,* oleoresin, essential oil and secondary metabolites are rich in spice crops, have more demand in the value-added product industries as well as developing countries. The quality of spices is determined based on its yield and quality attributes (*viz.,* essential oil, fiber and oleoresin and caryophylline content) along with volatile and non volatile constitutes of end product. Improvement of quality traits in spices has been implemented in different breeding methods but only few breeding methods *viz.*, selection, hybridization, and mutation are become more reliable. Hence, the production of quality aspect of spices work has to be carried out based on biotechnology and bio-molecular for better understanding of quality improvement of major spices.

**Key words:** Breeding programme, Quality attributes, Spice Crops

## Introduction

Spices are mainly used for conferring pungency, aroma, flavor and for seasoning of the food items. Most of these are utilized as the raw materials in medicine and perfume making industries. ISO have enlistednear about 112 species of plant as spices. India is enrichedwith over 100 species of spices and herbs and considered as a miraculous land of spices. The cultivated


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area under spices and herbs in India on about two million hectares and production accounting of 2.2 million tonnes and about 47% of the world business. There exist a huge diversity in India of some of its native spices *viz.,* tamarind,curry leaf, black pepper, cardamom, and to certain extent ginger, turmeric, garcinia and cinnamon. In fact there is no state in India that does not grow spices, which plays a significant role in the people lives and for their economic stability.

In recent years the export of Spice oil and oleoresins inflated in terms of value (Spices Board, 2015). Quality attributes *viz.*, oleoresin, volatile oil and secondary metabolites are rich in spice crops, with an excellent demand in the value-added production industry as well as in developing countries. Quality is the most important aspects which reflect to the consumer choices of the crops. Its parameters vary depending on the specific marketconsumption demand, based on which it has been categorised into two major classes*viz.*, external and internal quality. The "external quality" comprises tuber sizes, color, shape and depth of the eye of the fresh product which affect the consumer's preference. The category "internal quality" is given by characteristics of nutritional properties (*viz.,* quality of starch, sugar, protein content, flavor and dry matter), culinary value, cooking qualities or processing quality and quantity of glycoalkaloids.

**Black pepper**

It is botanically known as *Piper nigrum* L. and is popularly known as the 'King of Spices', is a very important agricultural commodity of commerce since time immemorial. It's one of the oldest and most vital spices notable to man. Black pepper is valued as an ingredient in food preparation and as a spice for its distinct pungency and taste. The total black pepper production in the globe is estimated at about 342,625 tonnes from an area of 583,897 ha in the year 2003. Kerala, Karnataka and Tamil Nadu are the foremost pepper producing states within the country, of that around 90% are contributed from Kerala. The average pepper productivity in India is one of the lowest in the world (303 kg/ha). The productivity of pepper per vine is highest (1kg) in Karnataka and lowest in Kerala (0.6kg).


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### Quality attributes in black pepper

The vlaue for this spice is generally determined by the piperineand volatile oilcontent in it . The variation on qualitative characters in black pepper has been investigated and cultivars were confidential based on quality characters (Gopalam and Ravindran, 1987). The quality of pepper is comprises by mainly two major components:

- Piperine content that is responsible for the pungency of the pepper
- Volatile oil which contributes the aroma and flavour. It's a mixture of volatile oil mainly monoterpene hydrocarbons (69.4-84%) and sesquiterpene hydrocarbons (15-27%).

### Quality specifications of pepper

| | Volatile oil (%) | Piperine (%) | NVEE (%) | Starch (%) | Crude fiber (%) |
|---|---|---|---|---|---|
| US specification | 2.0 (min.) | Not specified | 7.0 (min.) | 52 (min.) | 5.0 (max.) |
| Malasian specification | 2.2 | - | 8.1 | 59.2 | 5.0 |
| Indian sample | 2.5 | 4.6 | 7.6 | - | - |
| Sarawak sample | 2.0 | 4.7 | 8.7 | - | - |
| Muntok sample | 2.0 | 4.2 | 8.5 | - | - |
| Brazil sample | 2.0 | 4.3 | 8.7 | - | - |

**Pepper, a profile; CFTRI, Mysore, 1985**

### Variability of quality attributes in black pepper cultivars

| Traits | Cultivars |
|---|---|
| Higher Piperine | Kottanadan, Kumbakodi, Kuthiravally and Nilgiri |
| Higher Oleoresin | Balankotta, Kaniyakadan and Kumbakody |
| Higher dry recovery | Kalluvally |


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## Breeding methods for quality of black pepper

### Clonal selection

Two improved varieties are developed through germplasm selection namely Panchami and Pournami from IISR, Calicut. Panchami is a germplasm selection from Aimpiriyan with high fruit set, high yield and good quality, while Pournami was tolerant to root knot nematode – *Meloidogyne incognita*. These two cultivars have good yield characteristics. Panchami has medium long spikes (11.2 cm mean), high spiking intensity (77 spikes/100 nodes), high percentage of hermaphrodite flowers (91.5%) and high fruit set (82%). The spikes have a distinctive 5-row arrangement of fruits and the twisted nature of the spikes. It is a late maturing type; fruits mature for harvesting in about 8-9 months after flowering (Ravindran *et al.*, 1992). Pournami was selected based on its good yield potential and tolerance to root knot nematodes. PLD –2 is improved variety Release from NRC for Oil Palm, Regional Station, Palode during 1996 through clonal selection from Kottanadan. It is a late maturing type with yield potential of 2475 kg dry pepper/ha. PLD-2 has higher percentage of quality traits *viz.*, piperine (3.0%), oleoresin (15.45%) and essential oil content (4.8%).

### Selection from Open Pollinated Progenies:

Pepper, heterozygous segregation is always expected in the open pollinated (OP) and selfed progenies. Due to the geitonogamous mode of pollination, the open pollinated progenies are comparable to selfed off springs. Thus, there is a reasonable chance to situate useful genotypes in open pollinated progenies. Ibrahim *et al.* (1986) reported comparative genetic variability within open pollination of some varieties of pepper. At the Pepper research Station, Panniyur, developed three varieties namely Panniyur-2, 5 and 7 which were selected from OP progenies of cv. Balankotta, Perumkodiand Kalluvally,respectively. Panniyur-2 gives pepper of high quality with 6.6 % piperine and 10.9 % oleoresin and 3.4% oil. Panniyur-2 and 5 have good yield, medium long spike (12.3 and 13.1 cm), high bisexual flowers (97 and 96%), fruit set (74 and 87%), number of fruits/spike (74 and 103), fruit volume (120 and 104 cc/1000 fruits) and


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higher fruit weight (127 and 110g/1000 fruits). Panniyur-7is characterized by long spikes and high piperine content. IISR-Shakti, a high yielding variety tolerant to *Phytophthora* was also selected (P24) from open pollinated progeny of Perambramundi.

**Inter-cultivar Hybridization**

Information on the breeding value, general or specific combining ability of pepper cultivars is not available for selection of parental combinations. In the absence of such information the available gene pool is used at random for inter-cultivar hybridization with parents selected based on ossessing one or few good characters. Assessment of several progeny crosses at the PRS, Panniyur raise to the release of Panniyur-1 by selection from a cross between cv. Uthirancotta and Cheriyakanikkadan, having higher yield potential.

**Accessions short listed for different breeding traits**

| Trait | Germplasm accessions |
|---|---|
| Tolerance/resistance to foot rot disease | IISR Thevam, IISR Shakti |
| Resistance to Pollu beetle | Acession nos.816 (Neyyatinkara mundi), 841 (Veluthakaniyakadan), 1084 (Cheppukulamundi) and 1114 (Kumbhachola) |
| Tolerance/resistance to Slow wilt (nematodes) | Pournami, Acession nos.820 (Perumkodi), Hybrid 39 (Irumaniyan x Karimunda) |
| Tolerance to drought | Karimunda Selection (KS) 69, KS 51 and KS 114, 813 (Ottaplackal-II), 91 (Kalluvally) and 1495 (Kottanadan) |
| High caryophyllene content | Acession nos.840 (Vattamundi), 971 (Balankotta), 1019 (Vellamunda) and 1022 (Karimunda) |


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## Turmeric

*Curcuma longa* L. of Zingiberaceaefamilyis a herbaceous perennial herb. In our country, it is traditionally used for culinary purposes, religious, medicinal and also cosmetic and dye industry (Shah, 1997). In Ayurveda, turmeric is considered an aromatic stimulant, tonic, carminative and antihelminthic. The essential oil of turmeric is antiseptic and it is used in treating gall stones and gall complaints (Pruthi, 1976). In China, India, Indonesia, Thailand and throughout the tropics, including tropical part of Africa, America and Australia, it is extensively grown.Globally, India stands first position in term of both turmericproduction and export. In India, it was grown on an area of 223,000 ha and produced 1,190,000 tonnes of which 43000 tonnes was exported during 2013- 2014.

## Quality attributes in turmeric

### Organoleptic traits

- Coloring principle: curcumin (0.2-8.2%) has many medicinal properties
- Volatile oil:
  Turmeric oil is generally pale yellow in color with some peppery and aromatic odour, it contains 3–5 percent volatile oil which consists of nearly 60% turmeron, 25% zingiberene and few amount of d-sabinene,d-α-phellandrene, forneolandcineole.
- Oleoresin:
  Turmeric oleoresin is orange-red in colour and comprises of an upper oily layer and a lower crystalline layer. It resulted from the combination of different compounds *viz.*, volatile oil, curcumin and other active ingredients, non-volatile fatty and resinous material. It also contains appreciable quantities of protein (6.3%), lipids (5.1%), carbohydrates (69.7%) and fibers (2.6%).


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**Commercial quality specifications for turmeric in Europe**

| | |
|---|---|
| Colour | Germany- orange colour, Netherland - yellow colour, U.K -deep orange to yellow. |
| Taste | Powder of peppery odour and bitter taste |
| Volatiel oil | Germany- 3.5% (min.), Netherland-2% (min.), U.K -3.5-4% (min.) |
| Bulk density | 460-500 gm/L in ground powder |
| Curcumin | 3-7% (as per ASTA method 18) |
| Self life | 12 month |

**Variability for quality characters of turmeric cultivars**

| Characters | Range | Promising cultivar/accessions |
|---|---|---|
| *Curcuma longa* L. (*C. domestica* Val.) | | |
| Dry rcovery (%) | 13.5- 32.4 | Amrithapani,Cls No.5A, Ernad, Kothapetta |
| Oleoresin (%) | 10.0-19.0 | Palani, Kayyam, Gudalur,Amalapuram Sel. III, Chamakuchi, |
| Oil (%) | 4.0-9.5 | Amalapuram Sel. III, E.Sikkim, Ernad, Kakkayam local, Kahikuchi, Rorathong. |
| Curcumin (%) | 2.8-10.9 | CLLs 328,Edapalayam,erathukunnam, Gudalur,Kayyam, Kaziranga, Palapally,Jorhat, Sugandam, Trichur |
| *C. aromatica* Salisb | | |
| Dry recovery (%) | 14.0- 28.0 | Konni,Hahim,Burahazer, Dibrugarh. |
| Oleoresin (%) | 9.6-19.2 | Konni |
| Oil (%) | 4.0-9.0 | Armoor, Kasturi, Nadavayal. |
| Curcumin (%) | 2.3-8.0 | Dibrugarh |

(Ratnambal, 1986)

**Breeding methods for quality of turmeric**

**Clonal selection**

Clonal selection is the important tools for varietal improvement. Most of the improved varieties released so far are selections from germplasm or clonal selections based on location specific comparative yield evaluation trials mainly to identify turmeric types with higher potential for yield curcumin content and also curing percentage. Most of the selections have been


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made from different parts of the country by collecting their landraces. Improved selections were developed mainly in *C. longa* and to a lesser extent in *C. aromatica* and *C. amada*.

**Co-2:** It is clonal selection from local germplasm, release from TNAU, Coimbatore during 2012. It has higher curcumin content (4.02%), and resistant to rhizome rot. The rhizomesare strong, bright orange in colourand adopted to drought prone areas and also field tolerant to thrips, shoot borer, leaf folder & scale insects.

**Suvarna:** It is selection from Assam release from IISR, Kozhikode (1991). It has higher oleoresin (13.5**%),** curcumin(4.9%),essential oil (6.0%)and recovery of 20.4% (dry) . It is also field tolerance to rhizome rot.

**Sudharsana**: It is also germplasm selection from Singhat, Manipur, release from IISR, Kozhikode (1991). It has higher curcumin content (5.3%), oleoresin (15.0%), higher volatile oil (7.0%)and dry recovery (20.6%).

**Rajendra Sonia:** It isselection from local germplasm,release from Tirhut College of Agriculture, RAU, Dholi (1989). It has abold and plumpy rhizome with higher content of essential oil (5.0%), curcumin (8.4%) and dried recovery (18.0%).

**IISR Kedaram and IISR Alleppy Supreme** are improved variety through clonal selection, release from IISR, Kozhikode**.** It has characteristics of higher curcumin, oleoresin and dry recovery content with tolerant to leaf blotch disease.

**Mutation**

Induced mutations in turmeric were also tested. In TNAU,CO-1 and BSR – 1 selected from Erode local has been developed through mutagenesis, having higher yield with bigger rhizome size for farmer’s cultivation (Balashanmugam *et al.*, 1986). BSR-2 is another induced mutant from same Erode local using x-rays (Chezhiyan and Shanmugasundaram, 2000), which is resistant to scale insect. Suroma is mutant selection from Tsundur after irradiation with X-rays. Preliminary trials using Colchicine, EMS and MNG at 250, 500, 1000 PPM on cv. Mydukar


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resulted normal spouting in all treatments. Plant height and yields were more in colchicine treatments, number of leaves was more in EMS at 1000 ppm, but yield was poor.

## Ginger

*Zingiberofficinale* Rosc. has been considered to be the most important and old spices throughout the globe, belonging to family of Zingiberaceae. Its place of origin is still unknown but the evidences available hypothesised that it must have originated in South Asia to South East Asia. Nigeria accounts for about half of the total world area under Ginger, while India's contribution to global production is 30%. Australia stands first position in term of production of ginger confectionary products in the world. Although it is most commonly used as spice in culinary but it has immense medicinal value since time immemorial because of its antipyretic and aphrodisiac properties. Apart from its use as spices, it is also used in Indian systems of medicines (Aired, Sridhar and Unani) to treat liver problems, anemia, arthritis, flatulence, jaundice and rheumatism.

## Quality attributes in ginger

Based on the quality attributes, Jamaican and Indian ginger are considered to be the superior most followed by West African type. Jamaican ginger is known for its delicate aroma and flavour and is regarded as first grade type. Globally, Indian ginger is available in the form of ‘cochin’ and ‘calicut’ ginger in the market, tastes like lemonbite, which is peculiar character over Jamaican ginger. Chinese ginger is low in pungency and mainly exported as preservative in sugar syrup or as sugar candy. Nigerian and Sierra Leone dried ginger acquire somewhat camphoraceous and coarser odour and is rich in aroma and pungency factors and is more demanding for oleoresin extraction andoil distillation purpose . Fresh ginger, preserved ginger in syrup or brine and the dried ginger are the primary products of it especially used for flavouring purposes. And ginger powder, oils and oleoresins from dry ginger are the secondary products obtained from it.


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## Organoleptic traits

The major two compound *viz.*, gingerol (Fresh ginger), and shogaols (Dry ginger) are responsible for the pungent in ginger. The others organolptic traits are essential oil, oleoresin and low crude fibre content.

## Variability for quality traits of ginger cultivar

| S.No. | Character /trait | Cultivar Accession |
|---|---|---|
| 1 | High Dry recovery | Tura Local (29%), Tura (28%), Thodupuzha (22%), Kurupppampadi (23%), Nadia (22%) |
| 2 | High Oleoresin | Rio-de-Janeiro (10.5%), Assam (9.3%), Maran (10%) |
| 3 | High Essential oil | Mannanthody (2.2%), Karakkal (2.4%), Ellakallan (2.6%) |
| 4 | Least crude fibre | China (3.4%), UP (3.7%), Nadia (3.9%) |
| 5 | High Dry ginger yield (t/ ha) | Rio-de-Janeiro (3.27), Thingpruri (2.79), Maran (4.4), Nadia (3.8) |
| 6 | High zingiberene and gingerol | Bahrica and Amaravathi |
| 7 | Salted Ginger | Acc. Nos. 35 & 37 |

(Parthasarathy *et al.*, 2008)

## Breeding methods for quality of ginger

### Clonal selection

For crop improvement, major emphasis was placed on the enrichment of germplasm from different regions, their comparative yield analysis and better type selection based on yield and quality traits. The cultivars varied considerably in their rhizome characters and production potential which is influenced by various factors. The high yielding capacity of exotic variety Rio-de-Janeiro was proved in many locations. For quality attributes- Karakkal and IISR Rejatha


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had the highest volatile oil, Maran and Rio-de-Janeiro had the highest oleoresins, higher dry recovery in Suruchi, crude fibre was least in China, Nadia and Himgiri and high in Arippa, Kuruppampadi, Himachal Pradesh, Ernad Manjeri, Jugijan, Maran, Nadia, Poona, and Tura (Jogi *et al.,* 1978, Nybe *et al.,* 1980; Kumar *et al.,* 1980). Most of the improved varieties of ginger are the result of direct selections from germplasm.

**Somaclonal variation**

Regeneration of plantlets through callus section has been reported from leaf, vegetative bud, ovary and anther explants (Nirmal Babu 1997; Samsudeen *et al.*, 2001). This system could be used for inducing somaclonal variation as conventional breeding is interrupted due to the lack of seed sets. Evaluation of somaclones indicated variability with regards to different agricultural characters and other yield characteristics and also identified some promising high yielding lines with tolerance to rhizome rot (Samsudeen, 1996; Nirmal Babu *et al*., 1999, Nirmal Babu, 1997). Characterization and profile variations though RAPD also indicating genetic differences of these somaclones (Nirmal Babu *et al.,* 2003).

**Aswathy (IC NO. 0584128)** is Single plant selection from somaclones of cultivar Rio-de-Janeiro, release from Dept. of Plantation crops and Spices, KAU, Thrissur. It is high yielding with higher recovery of volatile oil and oleoresin percentage and having field tolerant to *Phyllosticta* leaf spot.

**Athira (IC No. 0584128)** and **Karthika (IC No. 0584129)** are improved variety selection from Somaclones of cultivar Maran, released from Dept. of Dept. of Plantation crops and Spices, KAU, Thrissur. These two varieties are tolerant to soft rot and bacterial wilt diseases and having higher volatile oil content.

**Cardamom**

Cardamom *(Elettaria cardamomum* Maton) well known as the ‘Queen of Spices’ is the most important spice of Zingiberaceae family and highly priced spices. It is frequently cultivated underneath evergreen forest trees of Western Ghats of South India mainly in Kerala, Karnataka


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and Tamil Nadu. India has been the world's largest producer of cardamom until 1979-80. Now Guatemala emerged as globe's premier producer and exporter of cardamom accounting for about 90 per cent of the global trade. Unlike in India, where cardamom is cultivated largely as a small holder crop it is grown on plantation scale in Guatemala.

**Quality attributes in cardamom**

Product with larger, round and uniform pods with a good dark green colour used to fetch the highest price in respect to the quality. Small cardamom having creeping panicles produces round fruits of uniform size and shape, attracting the buyers. Most of the bulks available in the market vary in shape and size, from round to longish fruits of nearly an inch in length, which leads to the results in admixture in the quality.

**Organoleptic traits:**

The major organoleptic traits in cardamom are cardamom aroma, volatile oil and oleoresin which mainly contains 1,8 cineole and α-terpenylaccetate. Beside that methyl eugenol, linalool, linalylaccetate and α-terpineol are also identified which are responsible for flavour characteristics compound.

**Breeding methods for quality of cardamom**

**Clonal selection**

Most of the improved varieties have been evolved by selection for desirable characters such as higher yield and quality capsule characters. Selection in cardamom is based on both qualitative and quantitative characters from preliminary, comparative yield trial and multilocation trials to confirm the superiority of the selected clone.

**ICRI -1 (Malabar type):** It is selection from germplasm, Mysore type and release from ICRI, Myladumpara, Kerala (1992). It has bold and green capsules with higher dry recovery (22.5%) and also tolerant to azhukal disease.


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**IISR Vijetha (NKE-12):** It is selection from field resistant plants for Katte (Malabar type), and release from IISR, Calicut (2001). It has bold capsules**,** resistant to katte virus and also field tolerant to thrips and borer.

**Selection from Open Pollinated Progenies**

Cardamom, being heterozygous segregation is always expected in the open pollinated (OP) and selfed progenies. Because of the antomophillus mode of pollination, the open pollinated progenies are comparable to selfed off springs. Thus, there is a fair chance to locate useful genotypes in open pollinated progenies.

**PV-2 (Vazhukka type):** It is selection from OP seedling of PV-1, release from CRS, Pampadumpara (2001). It has long bold capsule with higher essential oil content (10.49%) and higher dry recovery (23.8%).

**Mudigere-2 (Malabar type):** It is clonal selection from OP in Malabar type, release from RRS, UAS, Mudigere, Karnataka (1996)**.** It has round/oval bold capsules and higher 1,8 cineole content (45%)

**IISR KodaguSuvasini (CCS-1):** It is selection from OP progeny of CL-37 from RRS Mudigere (Malabar type), release from IISR, Calicut (1997)**.** It is tolerant to rhizome rot, thrips, and shoot/capsule borer.

**IISR Avinash:** It is selection from OP progeny of CCS-1 (malabar type) and release from IISR, Calicut (2001). It has dark green capsules**,** tolerant to rhizome rot, and shoot/capsule borer.

A large number of crosses have been made to combine high yield and resistance to rhizome rot and cardamom mosaic diseases, which are currently under evaluation at Indian Institute of Spices Research, Appangala. Varying degrees of significant positive heterosis was recorded in both the seedling and pre bearing stage of cardamom crosses (Padmini *et al.,* 2001). Based on *per se* performance, heterosis and combining ability, 15 hybrid combinations are short listed for further evaluation. Plant height, total tillers, bearing tillers and yield per plant were under the influence of non additive gene action (Prasath and Venugopal, 2001).


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**Conclusion:**

Although conventional breeding programmes *viz.*, selection, hybridization and mutation are become more successful for yield and quality enhancement of spices but still biotechnology and bio-molecular work has to be carried out for better understanding of quality improvement of major spices.

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