7

Black pepper

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7.1 Introduction

Among the spices, black pepper is the king. It is the most important, most popular and most widely used spice in the world. It has extensive culinary uses for flavouring and preserving processed foods and is important medicinally. Of the total spices traded internationally pepper accounts for about 34% (throughout this chapter, pepper is used to mean black pepper, unless otherwise stated). South West India is the traditional home of this important spice, particularly the Western coastal regions of South Peninsular India (the Malabar Coast).

Black pepper was the first oriental spice to be introduced into the Western world, and was well known among the Romans and Greeks. In the middle ages pepper assumed great importance in Europe. Its use resulted in revolutionary changes in Western cooking: together with other spices, pepper helped to improve flavour and preservation of food became easier. Pepper was also used in medicine, as a carminative and febrifuge, for aiding in digestion, and in curing the common cold.

7.2 Production and international trade

The genus *Piper* comprises about 1200 species, about 60% of which occur in central and northern South America. The other important regions are South and South-East Asia. Pepper is now grown in tropical zones such as the Asia Pacific region, mainly India, Indonesia, Malaysia, Sri Lanka, Thailand, China, Vietnam and Cambodia. Outside the Asia Pacific region the crop is distributed in Brazil, Mexico, Guatemala, etc., totalling about 26 countries (see Table 7.1). The total global area under pepper production is around 404,000 ha producing around 180,000 tonnes of pepper annually.

In 1950, 70% of world pepper cultivation was concentrated in India, but this had gone down to 46% by 1991 and production from 66% to 30%. India's share of the world market has come down from 56% to 23% in the same period. At the same time pepper production in other countries made remarkable progress. Currently India ranks first in

Table 7.1 Pepper production in producing countries 1996 to 1999 (in tonnes)

Country	1996	1997	1998	1999
Asia & Pacific	**153,988**			
India	60,000	60,000	65,000	75,000
Indonesia	39,200	43,291	56,250	44,500
Malaysia	12,000	18,000	19,000	21,500
Vietnam	20,000	25,000	22,000	30,000
China P.R.	8,000	NA	NA	12,000
Thailand	9,773	5,183	5,313	7,000
Sri Lanka	3,000	4,470	6,771	4,740
Cambodia	2,000	NA	NA	NA
Brunei Darus	15			
South Pacific	**168**			
Fiji	150			
Samoa	6			
Micronesia	12			
Latin America	**21,690**			
Brazil	19,500	18,000	17,000	22,000
Mexico	1,250			
Guatemala	380			
Honduras	400			
Saint Lucia	160			
Africa	**4,565**			
Madagascar	2,500			
Malawi	700			
Zimbabwe	700			
Benin	150			
Kenya	300			
Côte d'Ivoire	100			
Cameroon	65			
Ethiopia	–			
Zambia	50			
Total	**180,411**			

Source: Proc. Pepper Tech. Meet 1996. International Pepper Community (IPC) Jakarta Publications, 1997, 1998, 1999.

area followed by Indonesia and Brazil, while in production India ranks first followed by Indonesia and Vietnam. As far as productivity is concerned, Thailand ranks first (4089 kg/ha) and India is in the last position (311 kg/ha). The present status of area, production, productivity and export of pepper in the world is presented in Table 7.2. Export and percent production exported is presented in Table 7.3.

In India pepper is cultivated in an area of around 181,500 ha with an annual production that fluctuates between 60–80,000 tonnes annually (75,000 t in 1999 and 60,000 t in 2000). Kerala state is the major producer accounting for 72% of the crop, followed by Karnataka (22%) and the remainder is from Tamil Nadu, Andhra Pradesh and Goa. India started export of value added products of pepper in the 1970s. Until 1970 only small quantities of spice oil and oleoresin were manufactured and exported from India. Until that time pepper was exported only in the raw form and in bulk. Though there has been demand for diversified products of pepper, even now Indian export of black pepper is mainly in bulk and raw form.

Table 7.2 Area production and productivity and export of black pepper in major growing countries 1996/1999

Country	Area ('000 ha)	Production ('000 t)	Productivity kg/ha	Export ('000 t)	Production ('000 t)	Export ('000 t)
	1996				1999	
India*	197.50	60.00	304	35.07	75.00	47.32
Indonesia	128.67	39.20	305	34.00	44.50	35.53
Malaysia	8.80	12.00	364	14.80	21.50	21.59
Brazil	21.00	19.50	929	15.30	22.00	19.53
Sri Lanka	12.09	3.00	248	2.10	4.74	3.74
Thailand	2.39	9.77	4089	0.50	7.00	0.86
IPC countries	**370.36**	**143.47**	**–**	**101.78**	**174.74**	**128.57**
Vietnam	17.00	20.00	1176	75.00	30.00	28.00
China PR	11.18	8.00	716	5.00	12.00	
Madagascar	4.00	2.50	625	2.00	2.00	
Mexico	1.30	1.25	962	2.50		
Non-IPC	**33.48**	**31.75**		**84.50**	**44.00**	**28.00**
Total	403.93	175.22		136.28	218.74	156.57

Source: IPC 1997. Pepper Statistical Year Book 1995–96, IPC Jakarta, IPC Publications, 1999.
* Department of Economics and Statistics, New Delhi.

India, Brazil, Malaysia, Indonesia, Vietnam and Thailand are the main suppliers to the world market. Major importers of Indian pepper include USA, Russia, Canada, Germany, Italy, Netherlands, France, Japan, Morocco, Poland, UK, Canada and Saudi Arabia. The annual world export during 1988–93 ranged from 172,000–242,000 t. The value of world exports from 1988–93 ranged from US$270–569 million per year. The imports ranged from 174,000 to 216,000 t, valued at US$273–658 million. The export of pepper shows considerable change in recent years due to changes in the geographical composition from the 1970s and 1980s (Table 7.3). The projected world consumption of pepper by 2010 is estimated to be around 230,000 mt from the present production and consumption of around 180,000 mt. The consumption of pepper has undergone a steady increase in most consuming countries (Table 7.4) and the trend is expected to continue.

7.3 Description

Black pepper is obtained from mature fruits of *Piper nigrum* L., a perennial woody evergreen climber, native to the evergreen forests of the Western Ghats of South India (see Fig. 7.1). Under cultivation pepper vines are trailed over supports – either living trees or other supports, as columns 5–6 m tall and 1.0–2.0 m in diameter. The climbing woody stems have swollen nodes having clinging roots at each node, which helps in anchoring the vine to the support trees (standards). Pepper plants exhibit dimorphic branching, having two different types of branches: the straight upward growing (monopodial) main stem and orthotropic shoot climbing and remaining vegetative, adhering to the support with short adventitious roots at nodes. From the axils of leaves of orthotropic shoots, lateral shoots (plagiotropic branches) grow, and they have a sympodial habit of growth, having shorter internodes and without adventitious roots.

Table 7.3 Export ('000 t) and (%) production exported from major producing countries, 1995–99

Country	1995		1996		1997		1998		1999	
	Export	% production exported	Export	% production exported	Export	% production exported	Export	% production exported	Export	% production exported
Brazil	21.25	106.25	15.30	78.46	13.36	74.22	17.25	101.47	19.54	88.81
India	24.54	44.62	35.07	58.45	36.08	60.13	33.25	51.15	47.32	63.09
Indonesia	56.13	95.14	34.00	86.73	32.51	74.05	39.56	70.33	35.53	79.84
Malaysia	13.98	107.54	14.80	123.33	24.56	73.29	17.83	93.84	21.59	100.00
Thailand	0.91	8.31	0.50	5.12	0.51	9.85	0.50	9.42	0.86	12.28
Sri Lanka	2.40	64.34	20.10	48.72	3.28	73.38	5.49	81.09	3.74	78.90
IPC countries	**119.20**	**73.78**	**101.78**	**70.29**	**110.30**	**74.05**	**113.88**	**67.25**	**128.58**	**73.58**
Vietnam	15.00	75.00	15.00	75.00	23.5	94.00	22.00	100.00	28.00	93.33
China (PR)	5.00	60.39	5.00	42.25						
Madagascar	1.27	50.80	2.00	80.00						
Mexico	2.50	200.00	2.50	200.00						
Non-IPC countries	**23.77**	**74.21**	**24.50**	**69.01**						
Total	142.97	73.81	136.28	70.04						

Source: IPC, 1997, Pepper Statistical Year Book 1995–96, IPC, Kuningan, Jakarta. IPC Publications, 1999.

Table 7.4 Pepper consumption in developed countries (in grams)

	Countries	1975	1980	1990–95 (average)
1	Denmark	102	128	194
2	Germany	131	170	190
3	Belgium	90	127	181
4	USA	117	144	168
5	The Netherlands	94	91	151
6	Austria	97	141	150
7	France	107	124	138
8	Sweden	90	96	122
9	Canada	100	87	112
10	Switzerland	121	139	112

In such branches, as the growth proceeds, the terminal bud gets modified into an inflorescence (spike) and further growth is continued by the axilliary bud (see Fig. 7.2).

The pepper plant has a delicate root system and around 75% of the roots are confined to an area of 75 to 100 cm radius and depth (Jayasree *et al.* 1988). Inflorescence of pepper

Fig. 7.1 General view of a pepper vine.

Fig. 7.2 Spikes of pepper.

is a pendent spike (catkin) appearing opposite the leaf on plagiotropic branches. Spikes vary in length in cultivars, being 3–15 cm long with 50–150 flowers. The flowers are very minute, white to pale yellow in colour, arranged spirally on fleshy peduncles. The species is naturally self-pollinated, and pollination is by geitenogamy. The dispersal of pollen is aided by the presence of water droplets. The fruit is a single seeded drupe, but is often called a berry, sessile, small, usually globular, having fleshy pericarp and hard endocarp. The fruits are spherical in shape in most cases, obovate in a few and oblong in others. Fruits are green when young, changing to red on ripening.

Black pepper has a somatic chromosome number of 2n = 52, and is believed to be of hybrid origin. The meiosis is usually normal, and fertility high. Among the cultivars cv. *Vadakkan* is a triploid and has a somatic chromosome number of 2n = 78. The related species have chromosome numbers ranging from 2n = 26–132.

7.4 Cultivars and varieties: quality issues

The cultivars of black pepper have originated from the wild types. More than hundred cultivars are known and a few of them are still popular (Ravindran *et al*. 2000). The traditional pepper growing tracts have their own popular cultivars. Cultivar diversity is richest in the state of Kerala. Studies carried out in pepper growing belts identified specific cultivars/varieties suitable for different agroecological regions as well as for growing under different cropping systems. The important popular cultivars in India and other countries are given in Tables 7.5 and 7.6.

Black pepper is predominantly a self-pollinated crop. Variability for yield and quality characters are seen frequently among cultivars and within the same cultivar. Systematic research efforts in the last three decades has resulted in the release of 12 high yielding

Table 7.5 The important popular cultivars in India

Aimpiriyan, Arakkulam Munda, Blankotta, Cheriyakaniyakadan, Jeerakamundi, Kalluvally, Karimunda, Kottanadan, Karimkotta, Kuthiravally, Narayakodi, Neelamundi, Perambra Munda, Perumkodi, Thomankodi, Valiakaniyakadan, Vellanamben, etc., from Kerala and Uddagere, Doddigae and Malligesara from Karnataka.
Improved varieties: Panniyur 1, 2, 3, 4, 5, 6 and 7, Sreekara, Subhakara, Panchami, Pournami and PLD-2

Table 7.6 The popular cultivars in other countries

Brazil: Kuching (Singapura), Panniyuri 1
Malaysia: Kuching, Sarikei, Miri
Indonesia: Bangka, Banjarmasin, Belantung, Beng Kayang, Chunuk, Chunuk Kernuga (CK_2), Djambi, Duantebei, Kerenci, Kernuga (CK_1), Korintji, LDK (Lampung Daun Kocil), LDL (Lampung Daun Lebar), Palulauta, Petaling 1, Petaling 2, Merefin, Natar 1, Natar 2, LDLN1 (Lampung Daun Lebar Namang 1), LDLN2 (Lampung Daun Lebar Namang 2)
Sri Lanka: Ceylon
Madagascar: Sel.IV.1, Sel.IV.2
Thailand: Antique (Buffaloes Horning), Ban keow, Prang Thi, Prang Thi Bai yick, 'thick leaf'.

superior lines of black pepper through clonal selection, selection in OP progenies as well as through hybridization followed by selection in segregating populations.

The quality of black pepper is as important as yield and depends on the contents of piperine and essential oil. Variability of quality characters in black pepper has been investigated and cultivars were classified based on quality parameters (Gopalam and Ravindran 1987). Evaluation studies of germplasm collections resulted in identifying high piperine, oil and oleoresin types. Quality variations among common cultivars are given in Table 7.7. Essential oil varies from 0.4 to 7.0% while piperine from 2.0 to 7.4% among cultivars.

7.5 Cultivation

Though pepper is essentially a tropical plant requiring a hot humid climate, it can be grown in a wide range of environmental conditions. The characteristic and most suitable climate requirement for pepper are high rainfall, uniform temperature and high relative humidity, which is typical of the hot and humid tropical region. The plant requires equable climate, rainfall of 2000–4000 mm together with a mean temperature of 25–32ºC and RH of 65–95%. Pepper grows successfully between latitudes 20ºN and 20ºS, from sea level up to an altitude of about 1200 m above MSL. The sub-mountain tracts of Western Ghats of India up to about 1000 MSL are ideal for pepper cultivation. Rainfall in May–June initiates the flushing and flowering process, but once the process starts, there should be good precipitation until fruit development is over. Long spells of dry weather are unfavourable for the crop growth. Pepper yield is significantly correlated with the rainfall received during the first half of May and the cumulative total rainfalls in the second half of the year. In the pepper growing regions of Sarawak, Indonesia, Thailand and Vietnam the rainfall is well distributed having practically no drought period. Pepper grows in a wide range of soils with a pH of 4.5 to 6.9. The most favourable soil types are deep well drained brown red latosols or andosols, but the crop can grow well in deep

Table 7.7 Quality composition of important cultivars (values on dry weight basis)*

SL.No	Cultivar	Volatile oil % (v/w)	Oleoresin % (w/w)	Piperine % (w/w)	Starch % (w/w)
1	*Arikottanandan*	4.75	12.90	4.50	24.66
2	*Arakkulam munda*	4.75	9.84	4.40	36.18
3	*Blankotta*	5.12	9.35	4.26	25.20
4	*Ceylon*	3.75	3.50	7.60	15.66
5	*Cheriyakaniakkadan*	3.75	9.05	3.95	24.84
6	*Chumala*	2.25	5.45	3.30	46.62
7	*Doddigya*	2.50	7.10	2.85	36.00
8	*Kalluvally*	3.25	8.80	4.24	31.50
9	*Kalluvally (PTB)*	0.40	10.90	4.65	29.00
10	*Kalluvally type I*	3.00	8.44	5.40	20.70
11	*Kaniakkadan*	4.75	11.60	6.00	12.42
12	*Kottanadan*	2.50	17.80	6.60	23.40
13	*Karimunda*	4.00	11.00	4.40	39.60
14	*Karuvilanchy*	3.50	9.70	4.30	27.00
15	*Kumbbakodi*	4.50	14.90	7.60	18.20
16	*Kuthiravally*	4.50	14.90	5.97	14.04
17	*Munda*	4.75	7.00	5.60	22.70
18	*Mundi*	3.50	7.50	3.60	23.40
19	*Narayakkodi*	4.00	10.85	5.40	24.50
20	*Nilgiris*	5.50	15.50	6.05	23.60
21	*Palulauta*	3.00	7.60	3.60	19.26
22	*Panniyur I*	3.50	9.52	3.60	35.10
23	*Perumkodi*	3.00	8.60	4.00	28.80
24	*Perumunda*	4.00	8.00	7.40	26.64
25	*Shimoga*	2.50	7.20	4.56	17.64
26	*Sullia*	4.00	6.80	3.60	20.70
27	*TMB II*	2.50	10.80	5.80	32.60
28	*Uthirankotta*	4.75	8.55	3.92	28.80
29	*Vally*	2.50	6.53	4.90	16.02
30	*Aimpiriyan*	2.63	15.70	4.69	–
31	*Udhakara*	3.82	8.61	2.36	–
32	*Thommankodi*	5.98	13.77	2.77	–
33	*Sreekara*	7.00	13.00	5.10	–
34	*Subhakara*	6.00	12.40	3.40	–
35	*Panchami*	3.40	12.50	4.70	–
36	*Pournami*	3.35	13.80	4.10	–

*Ravindran *et al.* (2000b).

sandy clay as well if provided with mineral nutrition and adequate drainage. Purseglove *et al*. (1981) suggested that the ideal soil for pepper growing is well distributed alluvium rich in humus with pH above 5.5 or 5.8.

The cultivation system of pepper varies in different pepper growing countries. In India pepper is cultivated mostly in homestead gardens as a mixed crop and is seldom grown as pure plantation. In Sarawak, Thailand, Vietnam, Brazil, etc., pepper is grown mostly as a sole crop. Pepper vines are trailed on supports called standards, either live (on trees) or dead (such as concrete/wooden poles). Field planting of pepper vine is 3 × 3 m or 3 × 2 m (in sloppy lands). A spacing of 2.5 m × 2.5 m accommodating 1600 standards/ha or 3 × 3 m (1100 vines/ha) are commonly used. Before planting, the land is cleared, tilled and hoed. For planting pepper, pits of 50 × 50 × 50 cm are dug on the northern side of the standard at a distance of 15 cm. The pits are then filled with a mixture of top soil + FYM

+ Neem cake + bone meal, etc. Rooted cuttings are transplanted in the field during the rainy season. The best period for planting vines is at the beginning of the monsoon. Where the possibility of water stagnation exists, planting is carried out in August, or cuttings are planted on mounds.

Post planting management practices include tying vines to standards, pruning, shade regulation, basin management including mulching, weeding, intercropping, etc. During the initial growth phase shoots are tied to supports, and plants shaded. Mounds are to be maintained for dense rooting and to avoid water stagnation during the rainy season. Pruning is necessary to maximize production of fruiting lateral branches; but in India, Sri Lanka and Indonesia pruning is not practised. After three years plants grow to almost 2.5 m tall, have bushy appearance with many branches and a close canopy. In Sarawak, Malaysia, different pruning methods are adopted which result in thick bushy growth of plants.

A novel technique for raising black pepper and maintaining it in bush form has been developed. Instead of allowing the pepper vines to climb on supports (standards) as is usual, it can be grown as a bush so that it can be accommodated in homestead and terrace gardens. The fruiting lateral branches of any variety can be used to make saplings which start flowering in the same year and continue to yield throughout the year. Under good management a bush pepper plant grown in pots can yield an average of 100–150 g of dry pepper per pot/year (see Fig. 7.3).

It is essential that adequate and balanced fertilizers are applied to maintain the soil fertility and productivity of vines. A fertilizer dose of 100:40:140 NPK/ha is recommended for medium fertile soil in India. Depending upon soil nutrient status and location, specific fertilizer recommendations are also available. In the first two years the plants are to be supplied with half the dose of fertilizers in four equal applications. In India fertilizers are normally applied only twice a year, at the onset of monsoon and towards the end of the rainy season. In Sarawak, Thailand, etc., owing to the well-distributed rainfall, 4–5 fertilizer doses are given and this is one reason for the greater productivity in these countries. Pepper is grown as a rainfed crop in the majority of areas. Irrigation of vine during summer is beneficial. Diagnostic Recommendation Integration System (DRIS) was developed to quantify precisely the nutrients for sustainable black pepper production (Sadanandan 2000).

Insect pests and diseases are major constraints responsible for low productivity and crop loss in all pepper producing countries. Pepper is affected by several diseases that are caused by fungi, bacteria, virus and mycoplasma besides nutritional disorders. Diseases of pepper have been reviewed recently by Anandaraj (2000). Among the pepper diseases the serious ones are the foot rot caused by *Phytophthora capsici* f. *piperi*; pepper yellows (or slow decline) complex caused by the burrowing nematode (*Radopholus similis*) and *P. capsici;* and the virus disease (little leaf) caused probably by a Badna virus (see Anandaraj 2000, Ramana and Eapen 2000). Management programmes have been evolved to contain these diseases (Anandaraj 2000). In Brazil, *Fusarium* infestation is common and has led to large scale devastation of pepper, though the *Fusarium* etiology is still doubted. Infestation by insect pests is another factor responsible for low productivity of pepper in major growing countries. Insect pests of pepper have been reviewed recently by Devasahayam (2000). Pepper is infested by 56 general species of insects damaging various parts of vines such as root, stem, shoot, leaves, spikes and berries. However, depending on the severity and extent of damage, pollu beetle, top shoot borer, leaf gall thrips and scale insects could be considered as major pests. Successful chemical control measures are available for the management of insect pests.

Fig. 7.3 Bush pepper developed from a plagiotropic shoot.

Pepper vines attain full bearing from the fifth year onwards, though they commence yield from the second year. Light showers during May–June are considered beneficial for fruit set. Pepper plant starts flowering during May–June with the onset of the south west monsoon and harvesting is usually in December–January. Variation in maturity pattern depends on factors such as variety, rainfall, altitude, ambient temperature, etc. Pepper fruits mature in about 6–8 months after flowering. The period generally coincides with dry weather in India. The season of flowering and harvest of pepper varies from country to country (see Table 7.8).

Harvesting is carried out when one or more berries in some spikes turn orange to red colour. Entire spikes are picked when fruits are fully mature but still green (see Fig. 7.4). Pepper quality depends on maturity, processing and post-harvest handling. Advances made in the diversification of products and value added produce have necessitated harvesting of berries at different stages of maturity, to be regulated depending on the various end uses (Govindarajan 1977) (see Table 7.9).

Table 7.8 Season of black pepper flowering and harvest (Lawrence 1981)

Country	Flowering	Harvest
India	May–June	November–February (plains)
Bangka (Indonesia)	January–March	July–September
Lampong (Indonesia)	December–January	June–August
Brazil	February	August–November
Sri Lanka	November–December	March–May
Cambodia	June	January–March
Thailand	June–August	February–March
Sarawak	December–January	April–July

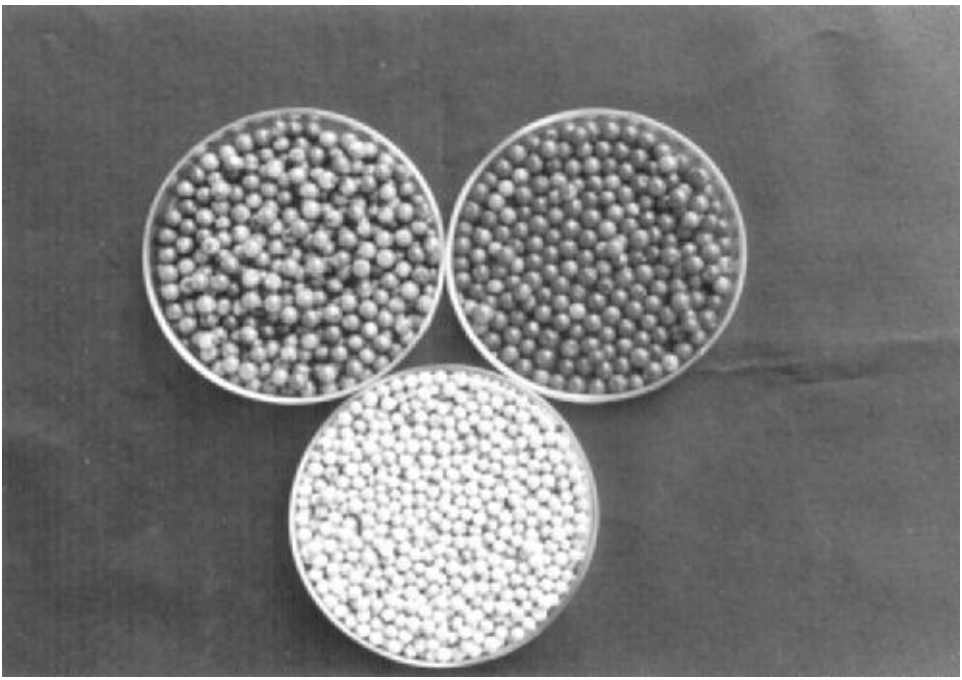


Fig. 7.4 Pepper berries (top left: fresh berries; top right: fully ripened berries; bottom: white pepper).

7.6 Handling after harvest

Post-harvest handling is crucial to get a high-quality product. The harvested spikes are kept in bags for 12–24 hours or heaped and covered overnight for a brief fermentation which makes despiking easy. The spikes are then threshed manually by rubbing or trampling underfoot or by using mechanical threshers of various types. Mechanical threshers are used only by large growers. Recently small-scale threshers are becoming popular in Sarawak and Indonesia. For a more detailed discussion on the topic, see Risfaheri and Nurdjannah (2000) and Zachariah (2000). Fruits separated by threshing are sun dried. Sometimes a blanching process is carried out before drying, by dipping fruits (in a wire basket) in boiling water for two minutes. The fruits are then spread out on the floor for drying. Blanching improves colour and also removes dust and adhering microbial contamination. Drying is done in the open sun in most cases. A black topped

Table 7.9 Pepper harvesting for various end products (Govindarajan 1977)

Products	Maturity at harvest
White pepper	Fully ripe
Black pepper	Fully mature and nearly ripe
Canned pepper	4–5 months after fruit set
Dehydrated green pepper	10–15 days before full maturity
Oleoresin	15–20 days before full maturity
Oil	15–20 days before full maturity
Pepper powder	Fully mature with maximum starch

Table 7.10 Size variations of different pepper cultivars/varieties

Large size (> 4.25 mm)	Medium size (3.25–4.25 mm)	Small size (< 3.25 mm)
Panniyur 1	Karimunda	Kurialmundi
Valiakaniakkadan	Arakulammunda	Narayakodi
Vadakkan	Ottaplackal	Nedumchola
Karuvilanchi	Kuthiravally	Jeerakamundi
Kanniakkadan		
Neelamundi		
Balankotta		

Table 7.11 Average composition of dried pepper (Pruthi 1993)

Content	% of composition
Moisture	8.7–14.0
Total nitrogen	1.5–2.6
Volatile ether extract	0.3–4.2
Non volatile extract	3.9–11.5
Alcohol extract	4.4–12.0
Starch	28.0–49.0
Crude fibre	8.7–18.0
Piperine	1.7–7.4
Total ash	3.6–5.7
Acid soluble ash	0.03–0.55

cement floor is the best for sun drying. Mechanical, electrical and solar dryers are also used for rapid drying. Dry recovery percentage varies among cultivars and growing conditions; usually the recovery ranges from 28–38%. After proper drying the moisture content should be around 10% only (for details see Ravindran 2000).

It is ideal to grade green berries using a mesh to remove the light berries and pinheads and classify based on size. Dried berries are also graded based on size. The size variations usually encountered with different cultivars/varieties are shown in Table 7.10. The average composition of dried pepper is given in Table 7.11 (Pruthi 1993). The dried pepper is cleaned to remove extraneous matter like dirt, grit, stones, stalks, etc., and berries are graded according to their size or density before packing.

7.7 Chemical structure

The quality of pepper is contributed by two components:

- piperine that contributes the pungency
- volatile oil that is responsible for the aroma and flavour.

Oleoresin of black pepper, produced by solvent extraction of dried powdered pepper, contains both aroma and pungency principles. Thus the chemistry of pepper is the chemistry of its essential (volatile) oil and piperine. The chemistry of pepper has been reviewed by Guenther (1952), Govindarajan (1977), Parmar *et al.* (1997) and Narayanan (2000).

7.7.1 Piperine

Piperine was first isolated by Oersted (1819) as a yellow crystalline substance. This alkaloid is the major pungent component present in pepper. In addition, five minor alkaloids possessing pungency have been identified in pepper extracts.

Piperine ($C_{17}H_{19}O_3N$; m.p 128–130ºC) is a weak base, which on hydrolysis with HNO_3 or aqueous alkali yields a volatile base piperidine ($C_5H_{11}N$). The acidic product of hydrolysis is piperinic acid ($C_{17}H_{19}O_4$). The structure of piperine is established as peperinic acid piperidide.

Piperinic acid exists in four isomeric forms: 2 *trans* 4 *trans* (piperine); 2 *cis* 4 *trans* (isopiperine); 2 *trans* 4 *cis* (isochavicine) and 2 *cis* 4 *cis* (chavicine). The synthesis of the isomers was carried out by Grewe *et al.* (1970) The structure of piperinic acid and its isomeric forms are given in Fig. 7.5. The three isomers of piperine are only weakly pungent. Piperine is highly sensitive to light. Irradiation of piperine in alcoholic solution produces a mixture of isopiperine and isochavicine.

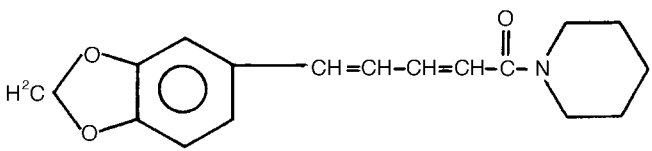
Piperine can be estimated by UV spectrophotometry by measuring the absorption maxima at 342–345 nm of a solution in benzine or ethylene dichloride. As piperine in dilute solution is highly photosensitive the solution should not be exposed to direct light.

Five analogues of piperine were isolated and characterized by various workers (Govindarajan 1977, Narayanan 2000). They are piperettine, piperanine, piperylin A, piperolein B and pipericine. The chemical structures of these analogues are given in Fig. 7.6. Parmar *et al.* (1997) listed the following alkaloids in addition to the piperine group of alkaloids mentioned above: brachymide B, guineesine, retrofractamide A, sarmentine, sarmentosine and tricholein.

7.7.2 Essential oil of pepper

The essential oil of pepper is a mixture of a large number of volatile chemical compounds. The aroma is contributed by the totality of the components. More than 80 components have been reported in pepper essential oil (Gopalakrishnan *et al.* 1993) (see Table 7.12). Only the important components are mentioned below (Narayanan 2000).

1. *Monoterpene hydrocarbons and oxygenated compounds.* This group includes: camphene, δ^3-carene, ρ-cymene, limonene, myrcene, *cis*-ocimene, α-phellandrene, β-phellandrene, α-pinene, β-pinene, sabinene, α-terpinene, γ-terpinene, terpinolene, α-thujene. Among them the major components are α-pinene, β-pinene, sabinene and limonene. The chemical structures of these compounds are given in Fig. 7.7. There



The structure of piperine

5(3,4-methylene dioxyphenyl) penta 2,4 -- dienoic acid piperidide

2 - trans,	4 - trans	Piperine
2 - cis,	4 - trans	Isopiperine
2 - trans,	4 - cis	Isochavicine
2 - cis,	4 - cis	Chavicine

Fig. 7.5 The structure of piperine.

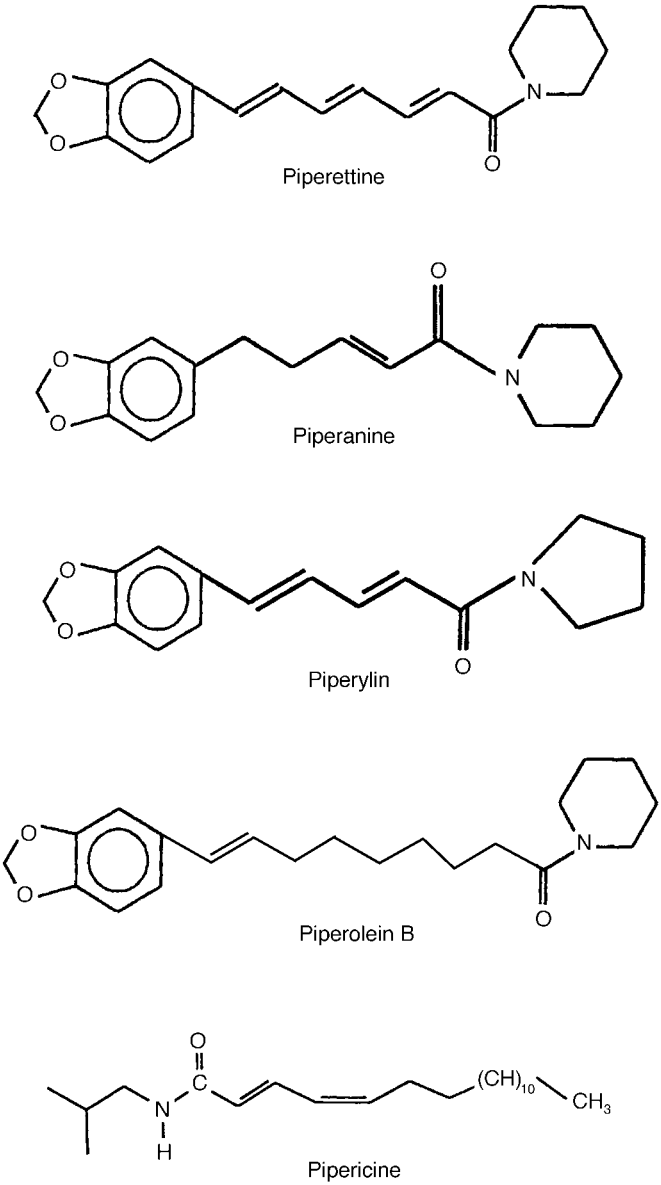


Fig. 7.6 Chemical structures of five analogues of piperine: piperettine, piperanine, piperyline A, piperolein B and pipericine.

are many oxygenated monoterpenoid compounds present in pepper essential oil, about 43 are known. They are: borneol, camphor, carvacrol, *cis*-carveol, *trans*-carveol, carvone, carventanacetone, 1,8-cincole, cryptone, ρ-cymene-8-ol, ρ-cymene-8-methyl ether, dihydrocarveol, dihydrocarvone, linalool, *cis*-menthadien-2-ol, 3,8,(9)-ρ-menthadien-1-ol, 1(7)-ρ-menthadien-6-ol, 1(7)-ρ-menthadien-4-ol, 1,8(9)-ρ-menthadien-5-ol, 1,8(9)-ρ-menthadien-4-ol, *cis*-ρ-2-menthen-1-ol, myrtenal, myrtenol, methyl carvacrol, *trans*-pinocarveol, pinocamphene, *cis*-sabinene hydrate, *trans*-sabinene hydrate, 1-terpinen-4-ol, 1-terpinen-5-ol, α-terpeneol,1,1,1,4-trimethylcyclo-hepta-2, 4-dien-6-ol, phellandral, piperitone,

Table 7.12 Comparative chemical composition of four pepper genotypes

Peak No.	Compound	Kovats index		Percent composition			
		Exp	Ref	1	2	3	4
1	α-thujene	931	938	0.73	1.26	1.59	0.91
2	α-pinene	943	942	5.28	6.18	5.07	5.32
3	Camphene	954	954	0.14	0.18	0.14	0.13
4	Sabinene	975	976	8.50	13.54	17.16	1.94
5	β-pinene	981	981	11.08	10.88	9.16	6.40
6	Myrcene	986	986	2.23	2.30	2.20	8.40
7	α-phellandrene	990	1002	0.68	0.20	–	2.32
8	δ-3-carene	1005	1009	2.82	0.18	–	1.03
9	α-terpinene	1008	1010	–	–	0.39	1.13
10	ρ-cymene	1018	1020	–	0.18	0.07	9.70
11	(Z)-β-ocimene + β-phellandrene	1022	1025/ 1025	–	0.15	0.23	0.37
12	Limonene	1039	1030	21.06	21.26	22.71	16.74
13	(E)-β-ocimene	1045	1038	0.18	2.84	0.30	0.17
14	γ-terpinene	1055	1057	0.01	0.49	–	0.03
15	Trans-sabinene hydrate	1057	1060	0.14	–	0.30	0.19
16	Terpinolene	1066	1074	0.10	0.20	0.22	0.08
17	Trans-linalool oxide (furanoid)[ti]	1082	1082	0.03	0.18	–	0.08
18	Unidentified	1085	1087	0.24	0.22	0.26	0.60
19	Linalool	1092	1092	0.22	0.22	0.46	0.28
20	Cis-p-menth-2-en-1 -ol+cis-p-menth-2, 8-diene-1-ol	1117	1111/ 1120	0.04	0.04	0.05	0.02
21	Trans-p-menth-2-en-1-ol	1128	1128	0.01	0.01	0.01	0.01
22	Citronellal	1134	1137	0.02	0.03	0.03	0.01
23	p-menth-8-en-1-ol	1154	1156	0.03	t	–	T
24	Borneol	1159	1164	t	t	t	T
25	Terpinen-4-ol	1170	1175	0.19	0.32	0.52	0.18
26	α-terpineol	1183	1185	0.10	0.17	0.12	0.07
27	Dihydrocarveol	1187	1188	0.01	–	0.02	0.02
28	p-menth-8-en-2-ol	1199	1208	–	0.01	0.02	0.02
29	Trans-carveol	1206	1209	0.01	0.01	–	0.02
30	Cis-carveol+carvone	1224	1222/ 1228	0.01	0.03	0.03	0.03
31	Piperitone	1245	1247	0.04	t	0.03	T
32	Carvone oxide*	1261	1261	0.01	0.01	–	0.01
33	Myrtenol	1277	1281	0.20	0.04	0.11	0.04
33(a)	Unidentified	1287	–	0.02	–	–	–
33(b)	Unidentified	1299	–	0.02	t	t	–
34	α-terpinyl acetate	1334	1333	0.86	1.22	1.33	1.05
35	Neryl acetate	1346	1345	0.20	0.07	0.05	0.13
36	Geranyl acetate	1364	1363	0.12	0.01	0.09	0.11
37	α-cubebene/δ-elemene	1376	1381	3.25	0.26	0.16	2.56
38	α-copaene	1384	1398	0.82	0.49	0.44	0.71
39	β-elemene	1403	1400	0.09	0.09	0.06	0.05
40	β-caryophyllene	1429	1428	21.59	27.70	23.29	21.19
41	Trans-∝-bergamotene	1431	1436	0.31	–	–	0.28
42	α-humulene	1435	1437	0.21	0.20	0.11	0.29

43	(E)-β-farnesene	1445	1448	0.08	0.22	0.03	0.13
44	α-amorphene	1451	1451	1.51	1.53	1.54	1.28
45	α-guaiene	1455	1454	0.11	0.07	–	0.10
46	Clovene[ti]	1460	–	0.14	0.07	0.07	0.13
47	Germacrene-D[ti]	1469	1469	0.04	0.03	0.04	0.26
48	Ar-curcumene	1474	1475	0.26	0.12	0.04	0.29
49	β-selinene	1480	1477	0.64	0.87	1.37	0.63
50	α-selinene	1483	1484	0.07	0.12	0.48	0.14
51	γ-muurolene	1489	1486	0.73	0.93	0.16	0.58
52	(E,E)-α-farnesene	1492	1494	0.72	–	0.47	0.72
53	β-bisabolene + α-bisabolene[ti]	1498	1496	4.25	2.15	3.10	0.49
54	δ-guaiene[ti]	1515	1502	0.82	0.17	0.09	1.85
55	Cuparene[ti]	1520	1518	1.38	0.09	0.14	0.04
56	δ-cadinene	1523	1524	0.12	–	0.07	0.13
57	(Z)-nerolidol	1530	1524	0.20	0.05	0.11	0.05
58	Elemol	1540	1540	0.11	0.06	0.07	0.08
59	Unidentified	1548	–	0.04	0.02	0.07	0.03
60	(E)-nerolidol	1551	1553	0.12	0.04	0.07	0.03
61	Caryophyllene alcohol	1557	1559	0.07	0.02	0.04	0.02
62	Unidentified	1566	–	0.03	0.11	0.07	0.07
63	Caryophyllene oxide	1570	1576	0.90	0.35	0.38	0.25
64	Unidentified	1582	–	0.06	0.04	0.05	0.05
65	Unidentified	1592	–	0.10	0.07	0.14	0.07
66	Unidentified	1598	–	0.10	0.03	0.05	0.07
67	Unidentified	1604	–	0.04	0.24	0.02	0.02
68	Cedrol[ti]	1608	1609	0.07	–	0.05	0.05
69	Unidentified	1614	–	0.38	0.24	0.22	0.27
70	A cadinol[ti]	1632	–	1.59	0.29	0.12	1.27
71	A cadinol[ti]	1639	–	0.26	0.12	0.15	0.25
72	Unidentified	1649	–	–	0.05	0.02	0.04
73	Unidentified	1651	–	–	0.05	0.05	0.12
74	β-Bisabolol	1666	1666	0.20	0.09	0.17	0.14
75	Unidentified	1687	–	0.06	0.02	0.02	0.04
76	Unidentified	1692	–	0.06	0.11	0.03	0.94
77	Unidentified	1712	–	0.02	0.07	0.06	0.02
78	Unidentified	1725	–	–	–	0.04	0.01
79	Unidentified	1778	–	0.09	–	t	0.16
80	Unidentified	1787	–	0.01	–	t	0.01
81	Unidentified	1823	–	–	–	0.04	–
82	Unidentified	1832	–	t	t	t	t
83	Unidentified	1858	–	t	t	t	0.05
84	Unidentified	1872	–	t	t	t	t
85	Unidentified	1876	–	t	t	t	t
86	Unidentified	1886	–	t	t	t	0.05
87	Unidentified	1900	–	t	t	t	0.03

Exp = experimental; Ref = reference; t = trace (<0.01%);
*correct isomer not given; ti = tentative identification; 1 = Panniyur-1; 2 = Panniyur-2;
3 = Panniyur-3; 4 = Panniyur-5.
(*Source*: Gopalakrishnan *et al.* 1993)

citronellal, nerol geraniol, isopinocamphone, methyl citronillate, methyl geranate, α-terpenyl acetate, terpenolene epoxide and *trans*-limonene epoxide.

2. *Sesquiterpene hydrocarbons and oxygenated compounds.* About 25 sesquiterpene hydrocarbons are present in pepper oil, the most important one being β-caryophyllene (Fig. 7.8). The others are α-*cis*-bergamontene, α-*trans*-bergamontene,

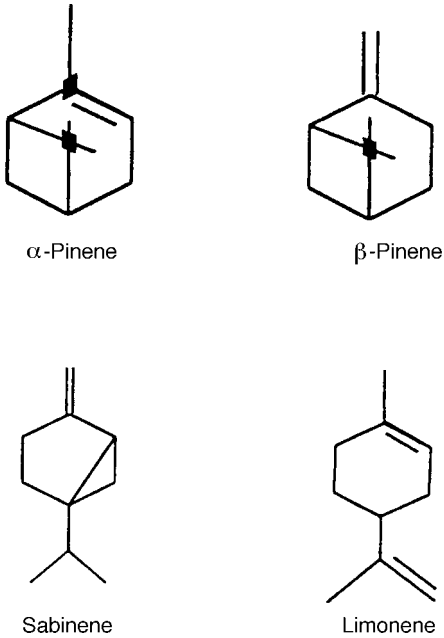


Fig. 7.7 Chemical structures of α-pinene, β-pinene, sabinene and limonene.

β-bisabolene, δ-cadinene, γ-cadinene, calamenene, α-copaene, α-cubebene, β-cubebene, ar-curcumene, β-elemene, δ-elemene, β-farnasene, α-guaiene, α-humulene, γ-humulene, isocaryophyllene, γ-muurolene, α-santalene, α-selinene, β-selinene, ledene, sesquisabenene and zingiberene. The oxygenated sesquiterpenes identified in pepper essential oil are: 5,10(15) cadinen-4-ol, caryophylla-3-(12), 7(15)-dien-4-β-ol, caryophylla-2,7 (15)-dien-4-β-ol, caryophylla-2-7 (15) dien-4-, β-ol, caryophyllene alcohol, caryophyllene ketone, caryophyllene oxide, epoxy-dihydrocaryophellene, *cis*-nerolidol, 4,10,10-trimethyl-7-methylene bicyclo-(2.0) decane-4-carboxaldehyde, γ-eudesmol, elemol, cubebol, α-bisabolol, β-bisabolol, viriideflorol, cubenol and epi-cubenol.

3 *Miscellaneous compounds*. In addition to the above groups of compounds many others were also identified in black pepper oil. They are: eugenol, methyl eugenol, benzaldehyde, *trans*-anethole, myristicin, safrole, piperonal, m-methylacetophenone, ρ-methylacetophenone, n-butyrophenone, methylheptanone, pinol, methyl heptanote,

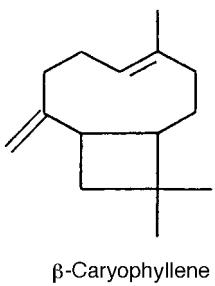


Fig. 7.8 Chemical structure of β-caryophyllene.

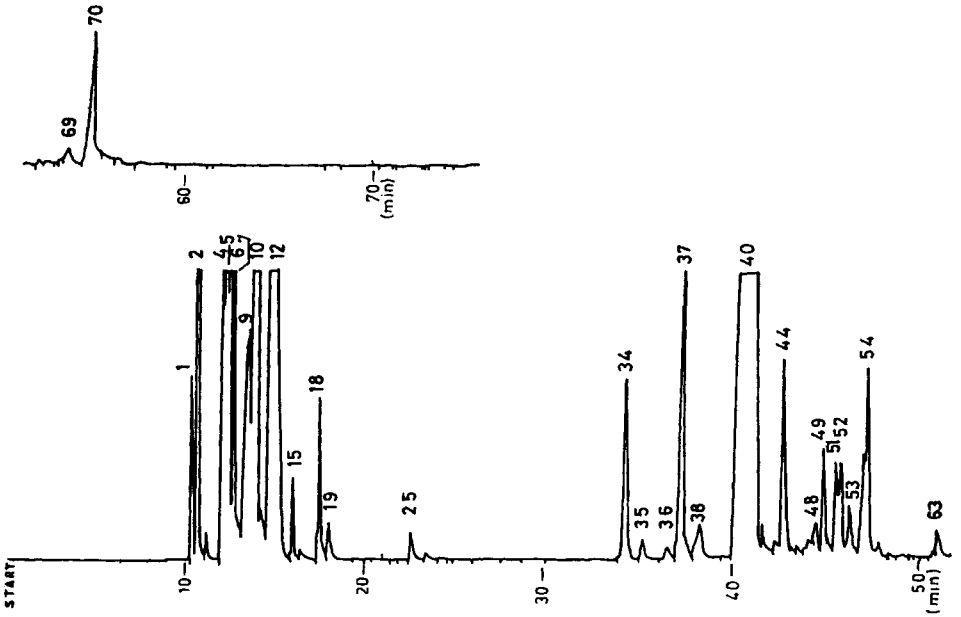


Fig. 7.9 Gas chromatogram of pepper oil (Panniyyur 5), 50 M methyl silicone column (Source: Gopalakrishnan *et al*. 1993).

methyloctanoate, 2-undecanone, n-nonane, n-tridecane, and aromatic acids such as benzoic acid, phenyl acetic acid, cinnamic acid, piperonic acid, butyric acid, 3-methyl butyric acid, haxanoic acid and 2-methyl pentanoic acid.

Compositional variations were reported among cultivars. Lewis *et al*. (1969) studied 17 cultivars from Kerala and found that the oil content ranged from 2.4–3.8%. In the oils, monoterpene hydrocarbons ranged from 69.4–84%, sesquiterpene hydrocarbons 15–27.6% and the rest were oxygenated constituents. The dominating monoterpene hydrocarbons were α-pinene (5.9–12.8%), β-pinene (10.6–35.5%) and limonene (22–31.1%). β-caryophyllene (10.3–22.4%) constituted the major sesquiterpene hydrocarbon. Significant differences in oil content and chemical constitution was reported by Russel and Else (1973) and Richard *et al.* (1971) who analysed the pepper samples from Lampong and Sarawak.

Gopalakrishnan *et al.* (1993) studied four genotypes (released varieties) of pepper using GC+MS employing methyl silicone capillary column. A model GC profile is given in Fig. 7.9. The oil of these cultivars possessed α-pinene in the range of 5.07–6.18%, β-pinene 9.16–11.08%, sabinene 8.50–17.16%, limonene 21.06–22.71% and β-caryophyllene 21.52–27.70%.

7.7.3 Phenolic components of pepper

The phenolic components of black pepper are a mixture of the glycosides of phenolic acids and flavonol glycosides. Parmar *et al.* (1997) listed the following flavonols from pepper: quercetin, isoquercetin, isorhamnetin 3-β-D-rutinoside, kaempferol 3-arabinoside, kaempferol-3-o-β-galactoside, quercetin-3-o-β-D rutinoside. Pepper also contains sitosterol. Grewe *et al.* (1970) found several lignans. One of them was identified as cubebin, which had been isolated earlier from *P. cubaba.*

7.8 Quality issues

7.8.1 Sensory quality evaluation of oil

The odour of pepper oil is described as fresh, dry-woody, warm-spicy and similar to that of crushed black peppercorn. Pangburn *et al.* (1970) made a sensory evaluation study of Malabar pepper oil after column chromatographic fractionation and mixtures of fractions at varying proportions. The early fractions were pepper like and floral and the late fractions pepper like, fresh and woody and the middle fractions falling in between. Govindarajan (1977) made extensive studies on odour analysis of pepper varieties. Using similar techniques Gopalakrishnan *et al.* (1993) described odour evaluation of four pepper varieties which they have examined by GC-MS. They depicted the odour profile on a four-point category scale and subjected the oils to ranking tests. The mean of the scores for each odour characteristic was plotted on radiating lines representing odour characteristic in sequential odour from left to right. The desirable odours are in the upper quadrants, the undesirable ones in the lower quadrants. The aromagram developed by these authors is given in Fig. 7.10.

7.8.2 Flavour and off flavour compounds

Jagella and Grosch (1999a, 1999b, 1999c) carried out some studies on the flavour and off flavour contributing components of black pepper. Their dilution and concentration experiments as well as enantio-selective analysis of optically active monoterpenes indicated that (+)-linalool, (+)-alpha-phellandrene, (-)-limonene, myrcene, (-)-alpha pinene, 3-methylbutanol and methyl propanol as the most potent odourants of black

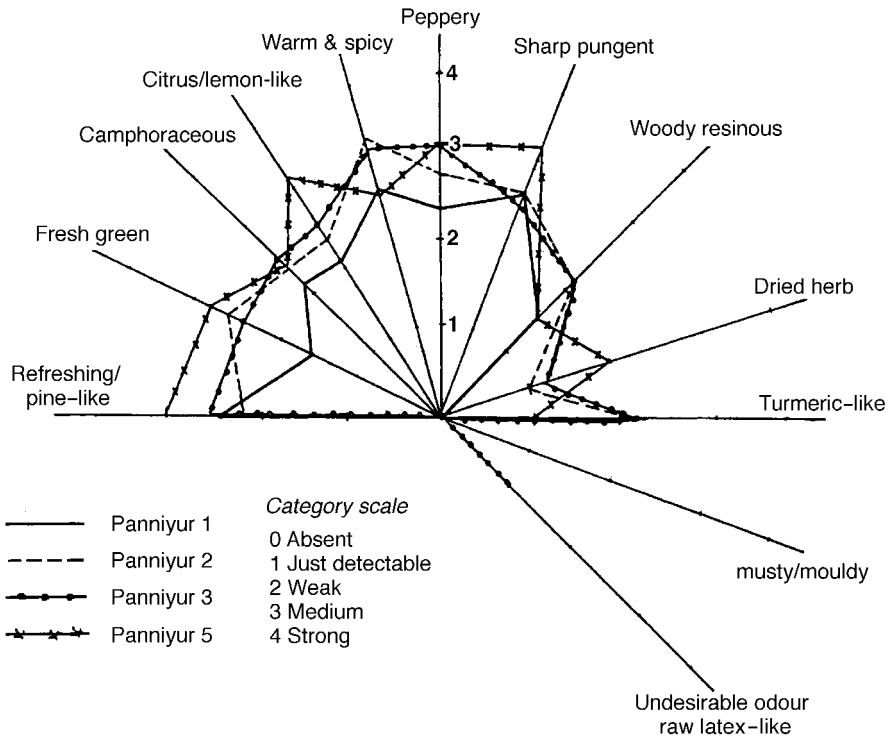


Fig. 7.10 Odour profilograms of pepper cultivars (Source: Gopalakrishnan *et al*. 1993).

pepper. The mouldy, musty off-flavour of Malaysian pepper is shown to be due to 2-isopropyl-3-methoxypyrazine and 2,3-diethyl-5-methylpyrazine. A storage experiment revealed that for ground pepper losses of α-pinene, limonene and 3-methylbutanal were mainly responsible for deficits in pepper-like, citrus-like, tepene-like and methyl notes after 30 days storage at room temperature. Jagella and Grosch (1999c) developed an aroma model for pepper based on the quantification of 19 odorants and calculation of their odour activity values. Omission tests conducted by them indicated that limonene, linalool, α-pinene, 1,8-cieole, piperonal, butyric acid, 3-methylbutyric acid, methyl propanal, 2- and 3-methylbutanal as key odorants of white pepper. The faecal off-flavour was caused by skatole and was enhanced by the presence of ρ-cresol.

7.8.3 Adulteration

The common adulterants used in whole or ground pepper are low quality pepper and various foreign matter. Synthetic compounds and cheap volatile sources are used to adulterate pepper essential oil (Sen and Roy 1974). Pepper berries are adulterated with stems, chaff or similar organic extraneous matter.

7.9 Industrial processing

The importance of value addition in pepper has been recognized by traders, and technologies have been developed for processing of pepper into a variety of products for consumer use. The pepper produced and dried at the farm level is subjected to grading and further processing. The dried pepper is sent through a variety of processing equipments such as mechanical sifter for removal of pinheads, vegetable seeds, sand dust and similar contaminants; and then to winnowing and destoning for removal of dust, stalks, light foreign matter and stones. These operations are now carried out in multiple-sieve cum air-classifier type of machine and gravity separators. From gravity separators pepper is conveyed to mechanical washers fitted with brushes for removal of dust, dirt, mould growth, etc., and for imparting a good shine to the product. The cleaned and washed pepper is then centrifuged to remove water, dried in a drier (usually diesel-fired or electric but with indirect heating). Finally the dried pepper is sent through spirals for final cleaning followed by sterilization either by steam or gamma radiation and packed in suitable polythene-lined packaging.

7.9.1 White pepper

White pepper is an important product mainly used in food items where the dark particles are undesirable, such as salad dressings, soups, mayonnaise, light coloured sauces, etc. White pepper is prepared from fully ripe fruits by removing the outer pericarp before drying. White pepper is produced conventionally from ripe berries by the water steeping and retting technique. Though other techniques were tested, they never found acceptance with consumers. In the water steeping and retting technique ripe berries and berries that are about to ripen are harvested, threshed and heaped in tanks through which water is allowed to run for 7–10 days. In Indonesia (which is the largest producer and exporter of white pepper) the pepper berries are tied in gunny bags and immersed in running water in streams or rivulets. During the process of water steeping the outer skin (pericarp) gets rotten and can be removed easily by rubbing and the deskinned fruits (seeds) are further

washed in clean water and sun dried. Often the deskinned fruits (seeds) are kept immersed in bleaching powder solution for a day or two to give better colour to the product. The yield of white pepper will be around one quarter instead of one third recovery of dry black pepper.

7.9.2 Ground pepper

In Western countries the most common form of black pepper available to the consumer is ground pepper. Ground pepper is produced by grinding dried, cleaned and sterilized white or black pepper in a hammer mill having copper tipped hammers. The ground pepper is then sieved in sieves of required mesh size and packed in airtight containers. The following points have to be kept in mind in the production of ground pepper (Ravindran *et al*. 2000a)

- Moisture level should be kept to a minimum as high moisture will affect the storage life.
- Volatile oil content should not be affected during the grinding process.
- Particle size should be optimum so as to ensure free flow for the duration of its shelf-life.
- Packaging should be airtight and safe.
- Microbiological cleanliness (freedom from moulds and bacteria) should be ensured.

A more recent development is cyrogrinding. In this new technique the grinding is done at low temperature to reduce the oil loss. This is done by injecting liquid nitrogen into the grinding zone and the temperature is adjusted suitably through the control of LN_2 flow rate. The cryogrind spice dispense more uniformly in spice formulations and the volatile oil and flavour loss are minimized.

7.9.3 Pepper oil

As already mentioned the aroma and flavour of black pepper is due to the essential oil content and this oil can be recovered by hydrodistillation or steam distillation. The essential oil contains monoterpenes, sesquiterpenes and their oxygenated derivatives having boiling points in the range of 80–200ºC. Industrial production of pepper essential oil is by steam distillation, by passing steam through pepper powder contained in a distillation chamber. The volatile oil that comes out along with the steam is collected in the condenser and later recovered, dried and stored in airtight containers.

7.9.4 Oleoresin

Oleoresin is commonly marketed as spice drops and contains the total pungency and flavour constituents of pepper. Oleoresin is produced by solvent extraction of pepper powder using a suitable organic solvent such as acetone, ethanol, ethyl acetate or ethylene dichloride. Either a one-stage or a two-stage process is employed for this. In the first case the oil is recovered along with the resins by solvent extraction. In the second process the oil is recovered by steam distillation followed by solvent extraction for recovering the oleoresin. Later the oleoresin and oil are blended to meet the required specifications. The organic solvent should be recovered completely from the oleoresin and the ISO as well as the importing countries have fixed maximum permissible limits for the approved solvents. The whole extraction process of oleoresin is usually done in batch extractors.

7.9.5 Supercritical fluid extraction (SFE)

SFE is the most versatile separation technology now being employed. It has a high extraction selectivity from a mixture of components because of the pressure-temperature dependent solubility in the solvents. The pepper raw material is loaded into the extractor and brought into contact with the supercritical solvent at relatively high pressures of 80–350 bar, at temperatures of 35–70ºC. The solute mixes into the supercritical solvent and both are passed through a pressure-reducing valve. The pressure on the separator side is about 40–60 bar, while the temperature is lower due to sudden expansion of the supercritical solvent. These conditions lower the solubility of the pepper raw materials in the solvent. When the material starts to separate, the gas is again compressed back to extract the material. Solvent recycling is achieved by means of a compressor (Anon. 1997).

Supercritical CO_2 is an ideal solvent for extraction of pepper, because it is cheap, abundant, inert, non-toxic, non-corrosive, non-inflammable and does not pollute the environment. Separation can be carried out at low temperature, residual solvent content can be reduced to near zero, solubility variation of active constituents can be easily manipulated, fractions can be extracted easily, the process consumes little energy, transfer rates are high and there are no fire hazards. Pepper extraction has been very successful with about 98% extraction of piperine and 81% of essential oil. The quality of the product is high compared to conventional extraction process.

The extracted oleoresin is also used for the separation of piperine by centrifuging the oleoresin in a basket centrifuge. From the oleoresin numerous secondary products have been developed having specified flavour strength and other properties. Such products include seasonings, emulsions, solubilised spices, dry soluble spices, encapsulated spices, heat resistant spices, fat based spices, etc.

7.9.6 Microencapsulated pepper

Microencapsulation is a recent development in which the flavour material is entrapped in a solid matrix, but releases the flavour when the product comes into contact with water or on heating. Methods such as spray drying, co-acervation, polymerization, etc., are made use of in microencapsulation. The process involves homogenization of the oil/water mixture in presence of the wall material followed by spray drying under controlled conditions. The wall materials used commonly include vegetable gums, starches, dextrins, proteins, cellulose esters, etc. A process known as CR-100, has been developed for microencapsulation which overcomes the limitations of the spray during process (Narayanan *et al.* 2000).

7.10 Pepper products

Much effort have been made in value addition of pepper and a variety of products have been developed. Such value added products are classified as 1) green pepper based products, 2) black pepper and white pepper based products, 3) pepper byproducts (Ravindran *et al*. 2000a).

(1) Green pepper based products:
- Canned green pepper in brine
- Bottled green pepper in brine

- Bulk packaged green pepper in brine
- Cured green pepper (without any covering tissue)
- Frozen green pepper
- Freeze dried green pepper
- Semidried or dehydrated green pepper
- Green pepper pickle in oil/vinegar/brine
- Green pepper-mixed pickle in oil/vinegar/brine
- Green pepper flavoured products
- Green pepper paste

(2) Black and white pepper based products:

- Black pepper powder
- White pepper powder
- White pepper whole
- Pepper oleoresin
- Pepper oil
- Microencapsulated pepper
- Other pepper products (such as soluble pepper, pepper paste)
- Byproducts from pepper waste

(3) Pepper based products:

- Many products, in which pepper is a major ingredient, have been developed such as lemon pepper, garlic pepper, sauces and marinades that have pepper as the main component.
- Spice mixtures and blends – curry powders and spice blends for various culinary uses.
- Pepper flavoured products such as pepper mayonnaise, pepper cookies, pepper keropak, pepper tofu, etc.
- Products using pepper extracts – pepper candies, pepper perfume, etc.

7.11 Functional properties

The nutritional composition of black pepper is shown in Table 7.13. Black pepper is an essential ingredient in the Indian systems of medicines – *Ayurveda*, *Sidha* and *Unani*, and is used as a curative agent for many maladies. Pharmacological studies have substantiated many of these traditional uses. (For a detailed discussion, see Vijayan and Thampuran, 2000.) Pepper has been seen as demonstrating a number of functional properties, including:

- analgesic and antipyretic properties
- antioxidant effects
- antimicrobial properties.

Piperine, the active ingredient in pepper, exerts substantial analgesic and antipyretic effects. Lee *et al.* (1984) found that piperine reduces inflammation in carragenin induced tests at an oral dose 50 mg/kg body weight. The anti-inflammatory effect was substantiated by Kapoor *et al.* (1993). Piperine and its homologues get absorbed through skin, and hence are capable of acting on the subcutaneous tissues as well as on nerves and blood vessels. The effect of pepper on the nervous system and on sexual organs (priapism) indicates anticonvulsive and vasodilatoral properties. Pepper also has an effect on lactation by increasing milk production. Pepper oil warms the skin and brings blood to the surface, stimulating circulation.

Table 7.13 Nutritional composition of black pepper per 100 grams

Composition	USDA Handbook 8–2[1]	ASTA[2]
Water (grams)	10.510	8.000
Food energy (Kcal)	255.000	4000.000
Protein (grams)	10.950	10.000
Fat (grams)	3.26[3]	10.200
Carbohydrates (grams)	64.810	66.500
Ash (grams)	4.330	4.600
Calcium (grams)	0.437	0.400
Phosphorous (mg)	173.000	160.000
Sodium (mg)	44.000	10.000
Potassium (mg)	1,259.000	1,200.000
Iron (mg)	28.860	17.000
Thiamine (mg)	0.109	0.070
Riboflavin (mg)	0.240	0.210
Niacin (mg)	1.142	0.800
Ascorbic acid (mg)	–	ND[4]
Vitamin A activity (RE)	19.000	19.000

[1] Composition of Foods: Spices and Herbs. USDA Agricultural Handbook 8–2, Jan 1977.
[2] The Nutritional Composition of Spices, ASTA Research Committee, Feb 1977.
[3] Piperine subtracted from lipid value.
[4] ND = Not detected.

In *Ayurveda*, pepper is used in the treatment of epileptic fits and to bring about sleep. Piperine exhibited protection against penetrazole induced seizure and also against electroshock seizure (Won *et al.* 1979). Piperine also possesses strong potentiating effect on hexobarbital induced hypnosis in mice. A compound of great interest extracted from pepper is 1-(3-benzodioxol-5yl)-1-oxo-2-propenyl-piperidide, known as antiepilepsirine, which was shown to have strong antiepileptic properties. This is used in Chinese hospitals for the treatment of epilepsy (Ebenhoech and Spadaro 1992).

Both pepper and piperine exert liver protective action. Kaul and Kapil (1993) found that piperine reduces *in vitro* and *in vivo* lipid peroxidation and prevents depletion of GSH (Gastricsulfhydryls) and total thiols. This is a very significant property, as lipid peroxidation causes free radical production that causes tissue damage. Pepper has antioxidant activity which is attributed to the tocopherol and polyphenol contents in pepper. Supercritical carbon dioxide extracts of ground black pepper have been found superior in reducing lipid oxidation of cooked ground pork (Tipsrisukond *et al*. 1998). The antioxidative activity of black pepper can, at least partially, be ascribed to the presence of glycosides of the flavonoids kaempherol, rhamnetin and quercetin (Vösgen and Herrmann 1980), as well as to the phenolic amides. Nakatani *et al.* (1986) established that all the five phenolic amides present in pepper possess very good antioxidant property, which is even superior to that of the synthetic antioxidants like butylated hydroxy toluene and butylated hydroxy anisole.

Addition of pepper to foods increases their keeping quality and prevents their spoilage, due to the antimicrobial properties of pepper. The essential oil of pepper is found to be inhibitory to *Vibrio cholerae*, *Staphylococcus albus*, *Clostridium diphthereae*, *Shigella dysenteriae*, *Streptomyces faecalis*, *Bacillus* spp., *Pseudomanas* spp., etc. Pepper oil stopped the growth and aflatoxin production by *Aspergillus parasitics* at a concentration of 0.2–1%. Pepper leaf oil also exhibits antifungal activity.

Pepper as well as piperine increases the bioavailability of medicaments including ampicillin and synthetic drugs as well as uptake of amino acids from food (Johri *et al.* 1992). Piperine seems to interact with the intestinal cells so as to increase the cell permeability. Piperidine is noted as a CNS-depressant, insectifuge, spinoconvulsant and urate solvent. The amides present in pepper have been shown to have insecticidal properties. Vijayan and Thampuran (2000) give a detailed account of the pharmacological and toxicological properties of pepper and piperine.

There is a current movement towards natural organic health supplements and medicines as substitutes for synthesized chemical drugs. The health promoting properties of pepper (as well as other spices) are being increasingly documented. Continued research is needed in this field to confirm their reported attributes.

7.12 Use of pepper in food

A spice is used in cooking for the following purposes:

- flavouring
- masking/deodorizing
- pungency
- colorant.

The spice interacts with the taste buds as well as other components of food leading to complex effects. A spice thus induces both direct and indirect (complex) effects as shown in Table 7.14 (Hirasa and Takemasa 1998).

Black pepper is the most widely used spice and occupies a proud place in the cusines of both West and East, with both vegetarian and non-vegetarian cooking. Black pepper contributes towards flavour, taste, antifungal, antibacterial and antioxidant properties, and hence pepper is a multifunctional spice, the predominating ones being taste and flavour.

Hirasa and Takemasa (1998) discuss the patterning theory of spice use and conclude that pepper is suitable for dishes of meat, seafood, milk, egg, grains, vegetables, fruit, bean and seeds and beverages. Pepper plays an important role in the cuisines of China, South East Asia, India, US, UK, Greece, Italy and France. In the case of cooking technique pepper is suitable for simmered, fried, steamed, deep-fried, food dressed with sauce, pickled and fresh food; but less suitable for baked food. The suitability pattern of pepper is represented in Fig. 7.11 (Hirasa and Takemasa 1998). There is almost no difference in suitability of pepper between Eastern and Western or continental cooking though it shows a very high suitability for American cooking.

Table 7.14

Direct effect	Indirect (complex) effect
Flavour	Increased appetite
Taste (pungency, bitterness, sweetness)	Masking effect
Colour	Improvement of texture and appearance
Antifungal effect	Preservation
Antibacterial effect	Preservation
Antioxidant effect	Preservation

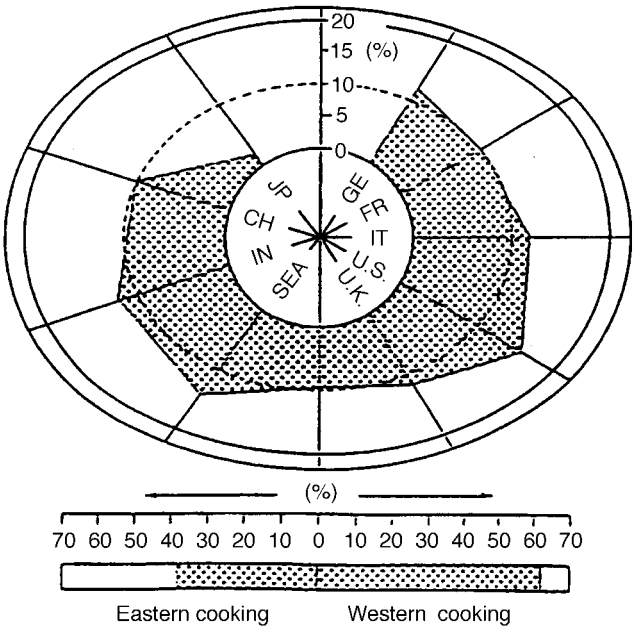


Fig. 7.11 Suitability pattern for pepper (*Source*: Hirasa and Takemasa 1998).

7.12.1 Use of pepper in curry powder

Pepper is an essential ingredient of most curry powders (masala mixes) used in cooking all over the world, but most extensively used in Indian as well as in South Asian cooking. There is an amazing variation of curry powders, to suit the hundreds of different 'curries' in the cuisines of these countries. Curry powders do play significant roles in the cuisines of other countries too. Curry powder is a mixture of coriander, cumin, turmeric, fenugreek, ginger, celery and black pepper and smaller amounts of chilli powder, cinnamon, nutmeg, clove, caraway and fennel, either with or without salt (Table 7.15). Many countries have their own specifications for curry powder. The federal specifications for curry powder (EE-S-631 J) are given in Table 7.16.

The famous oriental Five Spice Blend (FSB) used extensively in many meat and fish preparations has the following composition:

Ground cinnamon	25–50%
Ground anise (or star anise)	10–25%
Ground fennel	10–25%
Ground black pepper	10–25%
Ground cloves	10–25%

7.12.2 Soluble spice seasonings

Soluble seasonings are spice extracts mixed with a carrier like salt or dextrose. Oleoresin is used for the preparation of soluble spice. The most commonly used carrier is salt since the size of crystals provide good mixing action which disperses the oleoresin evenly (Tainter and Grenis 1993). But dextrose is preferred when a higher salt level is not desirable in the finished product. Soluble spices and seasonings are more often used in the processed foods industry, mainly because of the convenience involved in its use compared to the extracted

Table 7.15 Typical curry powder formulation indicating the range of spices (*Source*: Tainter and Grenis 1993)

Ingredient	Typical range (%)
Ground coriander	10–50
Ground cumin	5–20
Ground turmeric	10–35
Ground fenugreek	5–20
Ground ginger	5–20
Ground celery	0–15
Ground black pepper	0–10
Ground red pepper	0–10
Ground cinnamon	0–5
Ground nutmeg	0–5
Ground cloves	0–5
Ground caraway	0–5
Ground fennel	0–5
Ground cardamom	0–5
Salt	0–10

oleoresin or oil. For example pepper oleoresin is a thick, green, viscous liquid, difficult to mix uniformly and is not easy to pour, and is very difficult to measure when only small quantities are required. On the other hand, soluble black pepper is a free flowing powder, easy to weigh, and to add to a batch of products uniformly and accurately. Finally, waste is minimized compared to the oleoresin. When oleoresin is added it can lead to lump formation preventing uniform mixing, while the soluble salt ensures absolute uniformity while mixing. A typical soluble black pepper formulation consists of the following composition:

Oleoresin of black pepper	2–5%
Anticaking agent	up to 2%
Salt or dextrose	to make 100%

Pepper is an important ingredient in many flavouring and seasoning formulations – American, European as well as oriental. The contents of pepper in some of the well-known formularies are given in Table 7.17.

Consumers look for the organoleptic quality of foods rather than their nutritive value. Even the most nutritious food is not often accepted unless it is moderately spiced. It is an art to subtly blend flavouring and seasoning, to give distinctive tastes to the different dishes. All spices, particularly pepper, must be used with consummate skill. Even the

Table 7.16 Federal specifications (EE-S-631 J) for curry powder (*Source*: Tainter and Grenis 1993)

Ingredient	Limit (%)
Turmeric	37.0–39.0
Coriander	31.0–33.0
Fenugreek	9.0–11.0
Cinnamon	Not < than 7.0
Cumin	Not < than 5.0
Black pepper	Not < than 3.0
Ginger	Not < than 3.0
Cardamom	Not < than 2.0

Table 7.17 Pepper use in some of the flavouring and seasoning formularies (*Source*: Tainter and Grenis 1993)

Formulary	Content of pepper
Pickling mix	0–10%
Poultry seasoning	4.5–5.5%
Pumpkin pie sauce	0–5%
Oriental five spice blend	10–25%
Smoked sausage seasoning	6.57–7.03%
Italian sausage seasoning	2-6 oz/100 oz
Pork sausage	1–4 oz/100 oz
Bologna/weiner seasoning formulation	0.5–2% (oleoresin)
Roast beef rub formulation	0–5%
Pepperoni seasoning	1–4 oz/100 oz
Hot and spicy nut seasoning	0–5%

most insipid dishes can be improved by taking advantage of the pungent taste and spicy aroma of pepper to produce savoury dishes; that is why pepper is a universal favourite among the world's chefs. A list of oriental dishes where pepper is an essential component is given in Table 7.18.

Pepper is often used three times in the same dish before the food is eaten; first in the kitchen, as an ingredient in the dish; secondly, to correct or improve the overall seasoning during cooking; and thirdly at the dining table for the diners to add more spice and flavour to the prepared dishes.

Both white and black pepper are used. They are used whole, cracked, coarsely ground, medium ground or finely ground. Whole pepper corns are added as such to meat dishes, fish preparations, soups and pickles. Ground pepper is used in eggs, salads and gravies.

Table 7.18 Some important dishes flavoured with pepper

Beverages
1. Pepper tea
2. Pepper milk shake
3. Spicy water melon juice

Pickles/Chutneys
4. Pickled cherries
5. Pickled beef or pork
6. Pepper spike pickle
7. Coconut chutney
8. Fresh coriander chutney

Sweet preparations/confections
9. Quick banana pudding
10. Soji halwa

Snacks
11. Pepper biscuits
12. Vegetable crispies
13. Bonda
14. Pongal
15. Quick hamburger onion hash

Vegetable preparations
16. Vegetable curry
17. Vegetable korma
18. Masala del

Soups
19. Mixed vegetable soup
20. Cream of vegetable soup
21. Clear dhal soup

Legume/Pulse preparation to go with cereals
22. Radish sambar
23. Mulugutwanny (Rasam)

Meat dishes
24. Pepper steak
25. Black pepper pot roast
26. Pepper mutton balls
27. Black pepper fried chicken
28. Roghan josh
29. Korma curry

Other preparations
30. Amla preserve
31. French beans with coconut
32. Ground spice mixture

White pepper is popular in sauces and in preparations where pepper flavour is wanted but without the black specks.

Indian cooks use pepper and other spices in endless variations or combinations, and no two preparations have exactly the same combinations of spices. However, pepper is being used to a greater extent in American (US) cooking.

7.12.3 Masalas (spice mixes)

Though some foods such as fried potatoes, lady's finger (Okra), brinjal (egg plant), etc., use only two to three spices, most dishes are prepared with elaborate combinations of meticulously prepared and freshly ground spices referred to as masala. The masalas vary widely and each masala has a special purpose. Garam masala for example, is a blend of dried and powdered spices, to be used as such or in combination with other seasonings. Pepper has an important role in 'garam masala' along with cardamom, cloves and cinnamon. Premavalli *et al.* (2000) analysed various commercial brands of garam masala and 'puliyodara' mixes and found black pepper to be an important ingredient in all of them.

Pepper also is a must in freshly cut vegetable salads, such as cucumber, carrot, lettuce, radish, beetroot, onions, tomatoes, etc., in different combinations. Also, in the universally popular salad dressings, such as French dressing, pepper is a must. Further, as shown in the soup section of recipes (see Appendix), pepper is the only aromatic and piquant agent

Table 7.19 Sauce/seasoning and salad formulations containing pepper (*Source*: Farrell 1985)

Product	Ingredients
Sauce/seasoning	
Cucumber cream sauce	Lemon juice, cayenne pepper, white pepper, cream, mashed cucumbers
Cream sauce	Heavy cream, lemon juice, white pepper, onions, mustard
Sour cream sauce	Sour cream, lemon juice, white pepper, onions, egg, vinegar, dry mustard
Bearnaise sauce	Shallots, parsley, black pepper, terragon, chervil, vinegar, cayenne pepper, egg yolk, butter
Bechamel sauce	Chicken stock, butter, white pepper, onion
Diable sauce	Shallots, black pepper, white pepper, white wine, parsley, Worcestershire sauce
Horseradish sauce	Horseradish, white pepper
Poivrade game sauce	Onions, carrots, shallots, garlic, bay leaf thyme, vinegar, leaf stock, red wine, black pepper, parsley, olive oil, red currant jelly
Tourangelle sauce	Butter, onion, carrot, shallots, garlic, red wine, beef and chicken stocks, black pepper, parsley, bay leaf, thyme
Newburgh sauce	Mace, sherry wine, white pepper
Salad dressings	
Chicken	Capers, chives, curry powder blend, white pepper, fennel, marjoram, mustard, nutmeg, onion, paprika, poppy seed, rosemary, sesame seed, tarragon
Cabbage	Allspice, basil, white pepper, caraway seed, celery seed, dill, marjoram, mint, nutmeg, onion, chillies, poppy seed, paprika, rosemary, sesame, tarragon
Cucumber	Basil, capsicum, chervil, white pepper, dill, onion, paprika, terragon
Egg	Celery seed, chilli powder blend, white pepper, chives, chervil, dill, marjoram, mustard, onion, parsley, paprika, tarragon
Turkey	Capers, chives, curry powder blend, white pepper, marjoram, onion, paprika, poppy seed, rosemary, sesame seed, tarragon

Table 7.20 Commercial seasoning and instant gravy mixes containing pepper (*Source*: Farrell, 1985)

Name	% of pepper (white/black/oleoresin)
Frankfurter seasoning	
Formula A	5.72
Formula B	17.03
Formula C	3.73
Formula D	3.45 g (oleoresin) per 100 oz
Formula E	65.71 g/1000 oz (soluble spice in salt base)
Bologna seasoning	
Formula A	6.25
Formula B	0.37 (oleoresin)
Formula C	7.14 (soluble spice)
Fresh Pork Sausage seasoning	
Formula A	10.0
Formula B	7.5
Formula C	0.43 (oleoresin)
Italian seasoning	10.55
Italian sausage seasoning	10.0
Kielbase (Polish) seasoning	15.0
Smoked liver sausage seasoning	2.8 ground
Instant gravy mixes:	
Mushroom gravy seasoning and mix	0.46
Chicken gravy seasoning mix	0.33
Poultry gravy seasoning mix	0.026
Prawn gravy seasoning mix	0.46
French onion soup seasoning mix	0.004
Fish chowder seasoning mix	0.004
Chicken noodle soup seasoning mix	0.011
Shrimp seasoning mix	0.078
Fettucine Alfredo seasoning mix	1.0

in white sauces. Spikes of green pepper are used in a number of dishes in the households in Kerala, and Western Karnataka, India, where pepper is grown.

It is interesting to note that pepper goes into a variety of dishes, sweets and hot preserves and everyday dishes. It finds a place in exotic as well as bland preparations as in ‘Roghan Josh’ and in ‘Dhal Soups’.

A list of recipes using pepper compiled by Dastur and Maya (1981) is given in the Appendix.

7.12.4 Condiments, sauces, seasonings

Condiments are prepared food compounds containing one or more spices, or spice extracts, which when added to a food, after it has been served, enhance the flavour of the food (Farrell 1985). Condiments can be either simple (e.g. celery salt, garlic salt, onion salt) or compound (chilli sauce, chutney, meat sauce, mint sauce, prepared mustard, etc.). Pepper forms an ingredient in many compound condiments. Pepper powder constitutes around 0.02% in prepared mustard formulations such as Dijon and Dusseldorf mustards, while in Swedish mustard, pepper is around 0.2%. Pepper is an ingredient in certain

Worcestershire sauce formulations. It forms about 5.2% of the famous Marinara and Parmesan seasoning mixes.

Sauces are hot or cold liquid or semi-liquid products (other than a condiment), which when added to a food as it is being served, adds to its acceptance by improving its appearance, aroma, flavour or texture. It may or may not include spices or spice extracts. Pepper is a component spice in sauces, salad dressings and seasoning formulations (Table 7.19) (Farrell 1985).

Seasonings are compounds containing one or more spice extracts which when added to a food, either during its manufacture or in its preparation, before it is served, enhance the natural flavour of the food and thereby increases its acceptance by the consumer (Farrell 1985). Black and white pepper is an ingredient in many famous seasoning formulations and instant gravy mixes (Table 7.20).

7.13 References

Note: For a comprehensive treatment of all aspects of black pepper, see P.N. RAVINDRAN (Ed.) (2000) *Black Pepper*, Harwood Academic Publishers, UK.

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Appendix: Recipes with pepper (Dastur and Maya 1981)

In the following pages are presented recipes of some well-known dishes where pepper appears as an important ingredient.

Beverages

Pepper tea

Ingredients	*Approximate measure*
1. Water for 4 cups	
2. Tea dust or leaves	3–4 teaspoons (depending upon strength desired)
3. Pepper corns (coarsely powdered)	10–12
4. Sugar	6–8 teaspoons
5. Milk as desired	

Method

1. Place tea leaves and coarsely powdered pepper in a pot
2. Pour boiling water (98ºC is ideal) over the tea and pepper
3. Steep for 3 minutes and serve tea as usual with milk and sugar

Pepper milk shake

Ingredients	*Approximate measure*
1 Milk	$\frac{1}{2}$ litre
2. Sugar	10 teaspoons
3. Pepper corns (finely powdered)	8–10
4. Cashew nuts (finely cut and fried)	10–12

Method

1. Boil milk and sugar, stirring for about 20 minutes until it thickens a little
2. Chill
3. Garnish with pepper powder and cashew nuts before serving.

Note: This can also be served hot

Spicy water melon juice

Ingredients	*Approximate measure*
1. Water melon	1 medium sized
2. Pepper corn (powdered)	10

3.	Salt	a pinch
4.	Sugar	4 tablespoons (more if required)

Method
1. Cut water melon to fine pieces, remove the skin and seeds and pass through a blender.
2. Add salt and sugar and chill
3. Garnish with powdered pepper before serving.

Note: Tomato juice (fresh/canned/or pure beaten up) chilled can be garnished with powdered pepper and salt. This makes an excellent beverage in itself. It also serves as a base for several cocktails.

Pickles/chutneys

Pickled cherries

Ingredients		*Approximate measure*
1.	Cherries	1 kg
2.	Vinegar	$\frac{1}{2}$ litre
3.	Brown sugar	1 tablespoon
4.	Whole cloves	$\frac{1}{2}$ tablespoon
5.	Pepper corns	25–30
6.	Mace	2–3 pieces

Method
1. Put the cloves, pepper corns and sugar into the vinegar and bring to boil
2. Boil for 5 minutes and set aside to cool
3. Wash the cherries well and dry with a towel
4. Put the cherries in air-tight jars
5. Strain the vinegar and pour over the cherries, filling the jars to the brim
6. Seal well

Pickled pork or beef

Ingredients		*Approximate measure*
1.	Meat	500 gms
2.	Red chillies	6
3.	Cumin	$\frac{1}{2}$ teaspoon
4.	Mustard	$\frac{1}{2}$ teaspoon
5.	Turmeric	2.5 cm (1″)
6.	Pepper	25–30
7.	Ginger	2 inch piece
8.	Garlic	4–5 cloves
9.	Vinegar	$\frac{1}{2}-\frac{3}{4}$ litre

Method
1. Cut the meat into 2.5 cm (1″) cubes and wash in vinegar
2. Prick and rub well with salt and keep under a wt. for 24 hours
3. Wash the meat in vinegar and with the masala paste of ground red chillies, cumin, turmeric and mustard

4. Place the slices in a jar and sprinkle each layer with sliced ginger, garlic and pepper
5. Pour sufficient vinegar to cover the whole and shake the jar occasionally

Pepper spike pickle

Ingredients	*Approximate measure*
1. Green pepper spike	1 kg
2. Vinegar	600 ml
3. Garlic	1 pod (big)
4. Green chillies	10
5. Ginger	2 inch piece
6. Salt	$\frac{1}{2}$ cup
7. Turmeric	1 teaspoon
8. Oil	2 tablespoons

Method

1. Wash the pepper spikes, wipe and sprinkle over with salt and set aside for some time
2. Peel and slice garlic and ginger, slit green chillies
3. Heat oil. Add garlic, ginger and green chillies
4. Remove pan from fire and add turmeric, stir well
5. Add vinegar and salt. Bring to boil
6. Remove, cool and add prepared pepper spikes
7. Pack and store in airtight jars

Coconut chutney

Ingredients	*Approximate measure*
1. Coconut grated	5 tablespoons
2. Puffed Bengal gram dhal	2 tablespoons
3. Red chillies	1–2
4. Salt	1 teaspoon
5. Tamarind	a little ($\frac{1}{4}$ teaspoon)
6. Ginger	$\frac{1}{2}$ inch piece
7. Black gram dhal	1 teaspoon
8. Coriander leaves	1 bunch
9. Pepper	8–10
10. Mustard	$\frac{1}{4}$ teaspoon
11. Vegetable oil	1 teaspoon

Method

1. Grind together tamarind, salt, red chillies, puffed Bengal gram dhal, pepper, coriander leaves and ginger
2. Add coconut scrapings and grind again
3. Season with mustard and black gram dhal

Note: Red chillies can be replaced with green chillies.

Fresh coriander chutney

Ingredients	*Approximate measure*
1. Fresh lemon juice	3 tablespoons

2.	Water	3 tablespoons
3.	Fresh coriander stalks and leaves, thoroughly washed and coarsely chopped	10 medium-sized bundles
4.	Peeled finely chopped fresh coconut	1 big
5.	Finely chopped onion	1 medium
6.	Scraped, finely chopped fresh ginger root	$1\frac{1}{2}$ teaspoons
7.	Chopped red or green chillies	$1\frac{1}{2}$ teaspoons
8.	Sugar	1 teaspoon
9.	Salt	1 teaspoon
10.	Freshly ground black pepper	$\frac{1}{2}$ teaspoon

Method
1. Mix the lemon juice, water and the coriander and grind or blend at high speed for about 30 seconds
2. Add coconut, onion, ginger, chilli, sugar, salt and pepper and blend again
3. Add more sugar or salt if desired
4. Serve immediately. Can be kept in the refrigerator for 1 week

Note:
1. Mint or curry leaves can be substituted
2. If preferred traditional grinding stone can be used.

Sweet preparation in which pepper is used

Quick banana pudding

Ingredients		*Approximate measure*
1	Banana	4 large
2.	Coconut scrapings	1 cup
3.	Coarsely powdered pepper	$\frac{1}{4}$ teaspoon
4.	Jaggery	2 cubes

Methods
1. Peel bananas and slice
2. Add coconut scrapings and coarsely powdered jaggery
3. Add powdered cardamom and pepper and mix

Note:
1. Addition of thick curds to the above preparation will make it a dish to go with parotas or rotis
2. Jaggery can be substituted by sugar
3. If additional spiciness is preferred, $\frac{1}{4}$ teaspoon of dried ginger powder can also be added, and the quantity of sweetening agent increased slightly

Suji halwa

Ingredients		*Approximate measure*
1.	Wheat suji	1 cup
2.	Sugar	$1\frac{1}{4}$ cups

3.	Milk	1 cup
4.	Water	1 cup
5.	Raisins	10
6.	Cashew nuts	3
7.	Cardamom	2
8.	Pepper (dry powdered)	12
9.	Ginger (dry)	$\frac{1}{4}$ inch piece
10.	Fat	2 tablespoons

Method

1. Mix the sugar, milk and water and boil for a few minutes, and set aside
2. Mix wheat suji, fat and fry very slowly for 10 minutes
3. When suji becomes brown, pour the prepared syrup to the fried suji
4. Add raisins, cashew nuts and cook slowly until all the superfluous liquid is used up
5. Stir well with the ladle for 8–10 minutes
6. Then pour the halwa to a greased plate and cut into pieces
7. Sprinkle mixture of powdered cardamom, pepper and dried ginger

Snacks

Pepper biscuits

Ingredients		*Approximate measure*
1.	Wheat flour	3 cups
2.	Salt	$1\frac{1}{2}$ teaspoons
3.	Baking powder	1 teaspoon
4.	Fat	4 tablespoons
5.	Pepper	1 teaspoon
6.	Water	1 cup (slightly less)
7.	Sugar	$1\frac{1}{2}$ teaspoons

Method

1. Sieve wheat flour and baking powder
2. Add salt and freshly powdered pepper
3. Add fat and water and knead into a smooth dough
4. Roll and cut into biscuits and bake until light brown

Note:

1. These biscuits can also be deep fried
2. Addition of 1 teaspoon of powdered dry ginger and about 1 tablespoon of sugar and substitution of half the water with milk can also be done

Vegetable crispies (potato chips)

Ingredients		*Approximate measure*
1.	Potatoes	3 large sized
2.	Salt	to taste
3.	Pepper (ground)	$\frac{1}{2}$ teaspoon
4.	Oil for deep fat frying	$1\frac{1}{2}$ cups

Method
1. Wash and scrape potatoes
2. Slice into thin even circular slices
3. Keep in water to prevent browning and drain off water before frying
4. Deep fat fry a few slices at a time until crisp but not brown
5. Add salt and powdered pepper and shake

Note:
1. The other vegetables which can be used instead of potatoes are colocasia, yam, tapioca, sweet potatoes, plantatins, brinjals (large-sized) ash gourd skin
2. The vegetables can be cut into any desired shape such as finger chips, slivers, or thin slivers

Urd Bonda

Ingredients	*Approximate measure*
1. Black gram dhal	$\frac{1}{2}$ cup
2. Green chillies	2 (medium)
3. Ginger	$\frac{1}{2}$ inch piece
4. Pepper (whole)	30
5. Salt	to taste
6. Vegetable oil for frying	2 cups
7. Coconuts cut into small pieces	1 tablespoon
8. Coriander leaves	1 bunch (chopped)

Method
1. Soak black gram dhal for 4 hours
2. Drain water and grind into fine paste with salt ginger and green chillies
3. Add chopped coriander, cut coconut and whole black pepper to the ground dough
4. Divide into lime size portions and deep fat fry until brown

Pongal

Ingredients	*Approximate measure*
1. Rice	$1\frac{1}{2}$ cups
2. Green gram dhal	$\frac{3}{4}$ cup
3. Green chillies	4–5 chillies
4. Pepper corns	2–3 teaspoons
5. Ginger	1 inch piece
6. Fat	2 teaspoons
7. Cashew nut (optional)	20–22 nuts
8. Turmeric	$\frac{1}{2}$ teaspoon

Method
1. Chop green chillies and ginger
2. Heat fat and fry green chillies, ginger, pepper corns and turmeric
3. Fry the green gram dhal followed by rice, add water and salt and allow to cook
4. Garnish with fried nuts

Note:
1. Fresh chopped coriander leaves can be used for garnishing instead of cashew nuts

2. Green gram dhal can be substituted with other dhals such as (masur dhal) lentil and red gram dhal (tuar or arhar dhal)

Quick vegetable hamburger onion hash

Ingredients	*Approximate measure*
1. Minced onion	$\frac{1}{2}$ cup
2. Minced cooked carrot and turnip	$\frac{1}{2}$ cup
3. Butter or margarine	1 tablespoon
4. Finely chopped cooked potatoes	1–3 tablespoons
5. Salt	to taste
6. Ground black pepper	$\frac{1}{4}$ tablespoon
7. Garlic	2 cloves

Method:

1. Brown onion in butter or margarine
2. Add potatoes, salt, black pepper and ground garlic
3. Stir and cook 4 to 5 minutes
4. Serve hot with chapathi or bread

Note:

1. Addition of minced meat will make this a main dish
2. Left over vegetables can be used and spiced up with pepper and garlic, making a quick side dish for salt biscuits, rolls or buns

Vegetable preparations

Vegetable curry

Ingredients	*Approximate measure*
1. Vegetables	500 gms
2. Curd	4 tablespoons
3. Onion	4 medium
4. Garlic	8 flakes
5. Ginger	1 inch piece
6. Coriander	1 teaspoon
7. Pepper corns	10–12
8. Cumin seeds	$\frac{1}{2}$ teaspoon
9. Red chillies	3
10. Salt	to taste
11. Fat	1 tablespoon

Method

1. Clean and cut vegetables
2. Peel and slice garlic, ginger and onion
3. Soak garlic in a little water for 15 minutes
4. Pour this water over the vegetables and let it stand for half an hour
5. Heat fat, add sliced onion, vegetables soaked in garlic water and broken red chillies
6. In a thin muslin bag, tie the sliced ginger, pepper corns, cumin seeds and coriander seeds
7. Add in the muslin bag, salt and simmer until vegetables are tender

8. Remove the muslin bag with spices, squeezing out as much as possible of the juice into the vegetables
9. Add beaten curd and fry the vegetables until cooked

Note:
Cauliflower, potatoes, carrots, peas, knoll-khol, turnip and tomatoes can be used as vegetables, in convenient combinations

Vegetable khorma

Ingredients	*Approximate measure*
1. Vegetables (potatoes, carrots, beans, peas, double beans – any choice)	500 gms
2. Copra	1 tablespoon
3. Onion	3 medium
4. Ginger	1 inch piece
5. Garlic	3–4 flakes
6. Red chillies	4–5
7. Curd	$\frac{3}{4}$ cup
8. Coriander powder (dhania powder)	3 teaspoons
9. Khuskhus (poppy seeds)	2 teaspoons
10. Green chillies	2
11. Cinnamon, cloves, pepper corns and cardamoms	1 teaspoon
12. Fat	2 tablespoons

Method
1. Wash and cut vegetable
2. Soak in curd for half an hour
3. Grind together khuskhus, copra, garlic, ginger, coriander powder, red chillies (seed removed), green chillies and half the onion
4. Heat fat, fry remaining onion sliced
5. Add ground masala and vegetables. Fry for about 15 minutes over slow heat
6. Add remaining curd and tepid water and cook until vegetables are tender
7. Add cinnamon, cloves, pepper and cardamom roasted and powdered
8. Cook for 5 to 10 minutes more and serve hot

Masala dhal

Ingredients	*Approximate measure*	
1. Red gram dhal	1 cup	Grind to a paste
2. Red chillies	3	
3. Garlic	6 cloves	
4. Cumin	$\frac{1}{2}$ teaspoon	
5. Pepper corn	10	
6. Onions (sliced fine)	3	
7. Garlic (chopped)	1 clove	
8. Green chillies (slit)	2	
9. Cumin (jeera)	1 teaspoon	

10.	Fat (or ghee)	1 teaspoon
11.	Salt	to taste

Method
1. Cook dhal with salt, until half done
2. Fry the onions in $\frac{3}{4}$ of fat, add masala paste and fry until brown
3. Mix this in dhal and cook until tender
4. Remove from fire and mash dhal
5. Using remaining fat season dhal with cumin, green chillies and chopped garlic

Note:
1. In the place of red gram dhal, other split dhals cab be used, such as masur dhal (lentil), green gram dhal, dried field beans dhal
2. Addition of tamarind and a little jaggery add to variety

Soups

Mixed vegetable soup

Ingredients		*Approximate measure*
1.	Onion	2–3 small sized
2.	Potatoes	2 medium sized
3.	Tomatoes	2 medium sized
4.	Carrots	2 small sized
5.	Turnip	1 small
6.	Celery (if available)	2–3 stalks
7.	Salt	to taste
8.	Pepper corns	10–12
9.	Milk	$\frac{1}{4}$ cup

Method
1. Chop all cleaned vegetables
2. Cook in water until tender (meat stock can be used instead of water, if available)
3. Pass through a sieve or colander and make a purée
4. Add to purée, milk and powdered pepper just before serving

Note:
To add more body to vegetable soup, $\frac{1}{4}$ cup of red gram dhal or green dhal may be added. The dhal should be half-cooked first, before adding vegetables

Cream of vegetable soup

To the vegetable soup prepared as shown in recipe above, white sauce is added before serving instead of milk and pepper

White sauce

Ingredients		*Approximate measure*
1.	Maida	3 tablespoons
2.	Fat	3 tablespoons
3.	Milk	300 ml

4.	Pepper (powdered)	12–14
5.	Salt	to taste

Method

1. Melt the fat in a pan over slow heat
2. Stir in maida with a wooden spoon, and fry
3. Add milk gradually, stirring all the time, taking care that no lumps are formed and until creamy texture is obtained
4. Add powdered pepper and salt
5. Add white sauce to vegetable purée, heat and serve

Clear dhal soup

Ingredients		*Approximate measure*
1.	Red gram dhal	$\frac{1}{4}$ cup
2.	Onions	1 small
3.	Ginger	$\frac{1}{2}$ inch piece
4.	Pepper	10–12
5.	Salt	to taste
6.	Milk	$\frac{1}{4}$ cup
7.	Turmeric	a pinch
8.	Water (or meat stock)	about 2–2$\frac{1}{2}$ cups

Method

1. Cook red gram dhal with chopped ginger, onion and turmeric until soft and set aside
2. Decant the top clear portion
3. Simmer the stock and add salt
4. Add milk, let simmer for about a minute and remove from heat
5. Add freshly ground pepper and serve hot

Note:

1. The solid dhal portion can be used for other preparations
2. Other pulses like green gram dhal and whole pulses like cowpea and horsegram can be substituted for red gram dhal
3. Tomatoes may be added to the dhal or whole dhals at the time of cooking

Legume/pulse preparations to go with cereals

Radish Sambar

Ingredients		*Approximate measure*
1.	Red gram dhal	$\frac{1}{2}$ cup
2.	Radish	3 medium
3.	Coriander seeds	2 teaspoons
4.	Pepper	1 teaspoon
5.	Red chillies	9
6.	Black gram	1 teaspoon
7.	Bengal gram dhal	1 teaspoon
8.	Grated coconut	1 teaspoon

9.	Tamarind	1 medium sized lime ball
10.	Salt	to taste
11.	Fenugreek	$\frac{1}{4}$ teaspoon
12.	Turmeric	$\frac{1}{4}$ teaspoon
13.	Mustard	$\frac{1}{4}$ teaspoon
14.	Vegetable oil	1 teaspoon

Method

1. Roast coriander seeds, pepper, black gram dhal, Bengal gram dhal, red chillies and fenugreek together
2. Roast separately grated coconut
3. Grind all these ingredients together (wet sambar masala)
4. Clean wash and cook red gram dhal with turmeric
5. When dhal is half cooked add cut radish pieces
6. When radish is cooked add tamarind juice, salt and boil
7. Then add the wet sambar masala and boil for about 10 minutes
8. Remove from the heat and season with mustard and curry leaves

Mulugutwanny type or Rasam

Ingredients		*Approximate measure*
1.	Red gram dhal	2 teaspoons
2.	Red chillies	4
3.	Tamarind	$\frac{1}{3}$ lime size ball
4.	Pepper	2 teaspoons
5.	Curry leaves	a few
6.	Cumin	$\frac{1}{2}$ teaspoon
7.	Coriander seeds	1 teaspoon
8.	Turmeric powder	a pinch
9.	Mustard	$\frac{1}{4}$ teaspoon
10.	Salt	to taste

Method

1. Wash and cook red gram dhal
2. Add turmeric powder
3. Roast cumin pepper, coriander seeds and red chillies and grind
4. Extract tamarind juice
5. Add tamarind juice, salt to cooked dhal
6. Lastly add powdered ingredients and let them simmer for about 5–8 minutes
7. Season with mustard and curry leaves, and remove from heat

Note:

1. This is served as soup also, before main meals
2. Tomatoes can be used for extra flavour, and the quantity of tamarind is reduced

Meat dishes

Pepper steak

Ingredients	*Approximate measure*
1. 4 thick slices of beef or (fillet) pork	
2. Onions (chopped fine)	2 medium
3. Whole pepper (crushed)	1 tablespoon
4. Mustard	$\frac{1}{2}$ teaspoon
5. Red wine (optional can be replaced by tomato juice)	1 cup
6. Fat	for frying about 3–4 tablespoons
7. Salt	to taste

Method

1. Using a mallet, beat the crushed pepper and salt on the four pieces of meat
2. Heat a little fat and brown the steaks on either side
3. Lightly fry the onion in a little fat separately and pour over the steaks.
4. Mix mustard in one cup red wine (or 1 cup tomato juice) and put in the same pan as the fried onions
5. Heat and pour over the steaks just before serving

Black pepper pot roast

Ingredients	*Approximate measure*
1. Bottom round of beef	2–2$\frac{1}{2}$ kg
2. Tomato paste	1 can (180 gms)
3. Bay leaf	1 small
4. Pepper corns	1$\frac{1}{2}$ teaspoons
5. Salt	1$\frac{1}{2}$ teaspoons
6. Minced onion	1 teaspoon
7. Ground black pepper	$\frac{1}{2}$ teaspoon
8. Small new potatoes	8 small
9. Carrots	6 medium

Method

1. Brown meat on all sides in heavy kettle
2. Add tomato paste, 1$\frac{1}{2}$ cups water, bay leaf, whole pepper, salt and minced onion
3. Cover and simmer for 3 hours, basting frequently
4. Add ground black pepper, potatoes and carrots, continue cooking for 30 minutes or until meat is tender

Pepper mutton balls

Ingredients	*Approximate measure*
1. Minced onion	1 teaspoon
2. Ground mutton	$\frac{1}{2}$ kg
3. Eggs	2
4. Bread cubes	1 cup
5. Salt	1 teaspoon
6. Ground black pepper	$\frac{1}{2}$ teaspoon
7. Ground ginger	$\frac{1}{2}$ teaspoon
8. Ground nutmeg	$\frac{1}{4}$ teaspoon

9.	Cooking oil	4–6 tablespoons

Method

1. Mix minced onion with 1 tsp water, let stand for 5 minutes to soften
2. Combine with remaining ingredients
3. Shape into 1-inch balls or into bite-sized balls and brown on all sides in hot oil
4. Serve with spaghetti or on toothpicks as cocktail balls

Black pepper fried chicken

Ingredients		*Approximate measure*
1.	Chicken	1 broiler
2.	Milk	1 cup
3.	Ground black pepper	$2\frac{1}{2}$ teaspoons
4.	Flour	$\frac{1}{2}$ cup
5.	Fat for deep frying	
6.	Milk (for gravy)	1 cup
7.	Flour	$\frac{1}{4}$ cup
8.	Salt	to taste

Method

1. Place chicken in a shallow dish. Combine 1 cup of milk, 1 teaspoon ground pepper and $\frac{1}{2}$ teaspoon of salt and pour over chicken
2. Cover and refrigerate for 2 hours
3. Combine $\frac{1}{2}$ cup of flour, remaining pepper and salt
4. Cut chicken and coat with flour mixture and refrigerate again for 1 hour
5. Cook chicken in deep fat for 15 to 20 minutes until brown and tender, and set aside
6. Make cream gravy the following way:
   a. Place $\frac{1}{4}$ cup of fat from deep frying in a saucepan
   b. Blend in $\frac{1}{4}$ cup of flour
   c. Add milk (left over milk plus more milk to make $2\frac{1}{2}$ cups) until medium thick Stir and cool
   d. Add salt and pepper (remaining $\frac{1}{2}$ teaspoon)
7. Add gravy to fried chicken pieces and serve with naan or chapathi

Roghan josh and curried lamb

Ingredients		*Approximate measure*
1.	Lamb (mutton)	1 kg
2.	Chilli powder	$\frac{1}{4}$ teaspoon
3.	Salt	1 teaspoon
4.	Yoghurt (curd)	12 tablespoons
5.	Ginger (scraped)	$2\frac{1}{2}$ teaspoons
6.	Ghee and butter	3 tablespoons
7.	Black pepper freshly ground	5 teaspoons
8.	Turmeric	2 teaspoons
9.	Coriander leaves (chopped)	$\frac{1}{2}$ teaspoon
10.	Garam masala	$1\frac{1}{2}$ tablespoons
11.	Ground spice mixture	$\frac{1}{2}$ teaspoon
12.	Water	12 tablespoons
13.	Nutmeg (freshly grated)	a pinch

Method
1. Place mutton pieces in a large shallow baking dish and sprinkle on it chilli powder and salt evenly
2. Mix together curd and crushed ginger and pour over the mutton pieces, coating all the sides evenly
3. Close the dish tightly and marinade at room temperature for 1 hour
4. Heat ghee in a heavy frying pan and stir in a liberal grinding of black pepper and turmeric and then mutton and its marinade
5. Bring to a boil over high heat turning and stirring constantly
6. Reduce heat, close pan tightly and let it simmer undisturbed for 1 hour
7. Remove cover, sprinkle chopped coriander and pour 6 tablespoons of water, cover again and let simmer for 15 minutes
8. Repeat this using 3 tablespoons of water and cook until tender
9. Remove from heat and sprinkle the top with garam masala and nutmeg

Korma curry

Ingredients	*Approximate measure*
1. Mutton	$\frac{1}{2}$ kg
2. Sour curd	2 cups
3. Onion and garlic (finely chopped)	1 and 2 cloves respectively
4. Ground pepper	$\frac{1}{2}$ teaspoon
5. Ground ginger	$\frac{1}{2}$ teaspoon
6. Ground cumin seed	$\frac{1}{2}$ teaspoon
7. Ground chillies	$\frac{1}{2}$ teaspoon
8. Ground mustard seed	$\frac{1}{2}$ teaspoon

Method
1. Fry finely chopped onion in 3 tablespoons of ghee or other fat
2. Add the mixture of meat and spices and cook slowly until the meat is tender
3. Salt and a squeeze of lemon juice is added before serving
4. If possible, cook this curry without water or stock
5. The curds will help to form a thick gravy if cooked slowly

Note:
Grind the spices and add to the curd and marinade the mutton pieces in the spicy curd for about 2 hours prior to cooking

Other preparations

Amla preserve

Ingredients	*Approximate measure*
1. Amla	1 kg
2. Sugar	800 gms
3. Citric acid	1 teaspoon
4. Nutmeg	a small piece
5. Cloves	1 teaspoon
6. Pepper corns	1 teaspoon
7. Cardamom	1 teaspoon

Method

1. Powder all the spices coarsely except the pepper
2. Boil the amlas in water with a teaspoon of salt
3. Keep aside, covered with a lid, until cool
4. After cooling remove the seeds from the amlas and and keep the pieces aside
5. Dissolve the sugar in 700 ml of water, boil for about 10 minutes
6. Now add the amlas and citric acid to the syrup and boil for about 15 minutes until the syrup is thick
7. Add the powdered spices and the pepper, and remove from the heat after stirring well
8. Bottle when cool

French green beans fried with coconut

Ingredients	*Approximate measure*
1. Ghee or fat	3 tablespoons
2. Black mustard seeds	1 teaspoon
3. Black gram dhal	4 tablespoons
4. Finely chopped fresh ginger	1 teaspoon
5. Salt	1 teaspoon
6. Freshly ground black pepper	$\frac{1}{2}$ teaspoon
7. Green beans trimmed and cut across into paper thin rounds	$\frac{1}{2}$ kg
8. Chilli powder	1 teaspoon
9. Finely grated fresh coconut	3 tablespoons
10. Finely chopped fresh coriander	$1\frac{1}{2}$ tablespoons
11. Fresh lemon juice	$1\frac{1}{2}$ tablespoons

Method

1. Heat the ghee. Add the mustard seeds and black gram dhal and fry until the dhal browns lightly
2. Stir the onions, ginger, salt and chilli powder and drop in the green beans
3. Add the coconut and coriander, reduce the heat to low and cover the pan. Cook for about 10 minutes more, stirring occasionally until the beans are tender
4. Sprinkle with lemon juice, ground pepper corns for seasoning, and serve at once

Note:
In the place of French beans other vegetables which can be included are cluster beans, peas, tender cowpea, winged beans, cabbage, spinach and drumstick leaves

Ground spice mixture

Ingredients	*Approximate measure*
1. Three inch pieces cinnamon stick	5
2. Whole cardamom pods (preferably green cardamoms)	75 gm
3. Whole cloves	50 gm
4. Whole cumin seeds	50 gm
5. Whole coriander seeds	25 gm
6. Whole black pepper corns	75 gm

Method

1. Roast cinnamon, cardamom, cloves, cumin, coriander, pepper corns in one layer. Do not let the spices brown
2. Put the cardamom seeds, crushed cinnamon, cloves, cumin seeds, coriander seeds and pepper corns into a small pan or bowl and stir them together until they are well mixed
3. Grind the spices in convenient batches by pouring them into the jar of an electric mixer, blending at high speed for 2 to 3 minutes, until they become a smooth powder. As each batch of spice is ground, transfer it to a jar or bottle with a tightly fitting lid.
4. Garam masala may be stored at room temperature in an airtight container, and will retain its full flavour for 5 to 6 months

Note: In most homes, the traditional stone grinder is used.