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Allspice

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Abstract: The evergreen tree *Pimenta dioica* provides the culinary spice pimento or allspice of commerce. The dried, mature but not ripe, berries are the spice of commerce. Pimento is also sold as ground spice. The extraction and chemical composition of other commercially important products obtained from the spice, like berry oil, leaf oil and oleoresin, are detailed. Cultivation, propagation and post-harvest processing are reviewed in the chapter. The use of allspice in food, medicine and perfumery and the functional properties are also described. Cleanliness, safety issues and trade specifications are also enumerated in the chapter.

Key words: adulteration, allspice, berry oil, chemical composition, cultivation, oleoresin, quality, trade specifications.

9.1 Introduction

Allspice, *Pimenta dioica* (L.) Merr. (syn: *P. officinalis* Lindl., *Myrtus pimenta* L., *M. dioica* L. and *Eugenia pimenta* DC (Merrill, 1947) is a polygamodioecious evergreen tree, the dried unripe fruits of which provide the culinary spice pimento. It belongs to the family Myrtaceae and is known in English as allspice or pimento, in French as *piment jamaique* or *toute-epice,* in Portuguese as *pimenta da Jamaica* and in Spanish as *pimiento gorda*. The vernacular names of allspice are given in Table 9.1. The name allspice was coined by John Ray, an English botanist, who identified the flavour as a combination of clove, cinnamon and nutmeg.

The word pimento is derived from the Spanish word *pimienta* for black pepper, as allspice resembles peppercorns. It is known as pepper in many languages. In Russian it is known as *Yamaiskiy pjerets* – Jamaica pepper; in French *poivre aromatique* – aromatic pepper; in German *Nelkenpfeffer* – clove pepper; and in Swedish as *kryddpeppar* – condiment pepper. Newspice (German *Neugewurz*) also refers to its origin from the New World and the French *toute-epice* reflects the complex aroma of this spice. However, the berries were widely known as *pimienta,* later anglicized as pimento. The genus name *Pimenta* was derived from the Spanish *pimiento* for black pepper. Since the Spaniards initially called allspice pimiento, the name was also introduced to many European countries along with the spice when the spice was introduced to Europe in the sixteenth century. The species name *dioica* (Greek *di-* from *dyo* 'two', *oikos* 'house') indicates that the functional male and female flowers grow on different plants.

Table 9.1 Vernacular names of allspice (*Pimenta dioica*)

Language	Vernacular name
Arabic	*Bahar, Bhar hub wa na'im*
Danish	*Allehande*
Dutch	Jamaica pepper, piment
English	Jamaica pepper, myrtle pepper, pimento, newspice
Estonian	*Harilik pimendipuu, Vurts*
Finnish	*Maustepippuri*
French	*Piment, piment Jamaique, poivre aromatique, toute-epice, poivre de la Jamaique*
German	*Piment Neugewurz, Allgewurz, Nelkenpfeffer, Jamaicapfeffer, Englisches Gewurz*
Hungarian	*Jamaikai szegfubors, Szegfubors, Pimento, Amomummag*
Icelandic	*Allrahanda*
Italian	*Pimento, pepe di Giamaica*
Norwegian	*Allehande* Polish
	Ziele angielskie
Portuguese	*Pimenta da Jamaica*
Russian	*Yamaiskiy pjerets*
Spanish	*Pimienta de Jamaica, pimienta gorda*
Swedish	*Kryddpeppar*
Turkish	*Yeni bahar*

Source: http://www.uni-graz.at/~katzer/enal/Pime_dio.htm.

9.1.1 Origin and distribution

The family Myrtaceae consists of about 3000 woody species, most of which grow in the tropics. The genus *Pimenta* Lindl. consists of about 18 species of aromatic shrubs and trees native to tropical America (Willis, 1966). The genus is closely related to *Myrtus* L. and *Eugenia* L. The commercially important *Pimenta* spp. is *Pimenta dioica* (L.) Merr. providing the spice pimento (allspice) and *P. racemosa* (Mill) Moore, bay or bay rum tree providing oil of bay. The basic chromosome number for the genus is $x = 11$ and allspice is a diploid with $2n = 22$ (Purseglove *et al.*, 1981).

The tree is indigenous to West Indies (Jamaica). The trees are also found in Central America (Mexico, Honduras, Guatemala, Costa Rica and Cuba) and in the neighbouring Caribbean islands, although its original home is in dispute. Christopher Columbus discovered allspice in the Caribbean islands in about 1494. Spanish explorers and later settlers in Jamaica harvested and used the leaves and berries. Reports indicate that, there has been continuous production of berries in Jamaica from about 1509 to the present day. The berries reached London in 1601 as described by Clusius in his *Liber Exoticorum* and the plants were first cultivated in England in a hot house in 1732 (Weiss, 2002). Before World War II, allspice was more widely used than today; however, during the war many trees were cut down and there was a shortage of the spice. Although cultivation was taken up after the war, production never fully recovered.

Allspice was introduced into West Indian Islands (Grenada, Barbados, Trinidad and Puerto Rico) from its place of origin. Attempts to introduce it into countries in tropical regions, namely, India, Sri Lanka, Fiji, Malaysia, Singapore and Indonesia (Java, Sumatra), have, for various reasons, not succeeded fully. In India, there are a few trees in Maharashtra, Tamil Nadu, Karnataka and Kerala.

9.1.2 Production and trade

Jamaica is the largest producer and exporter of pimento, accounting for 70 % of the world trade. The remaining 30 % is produced by Honduras, Guatemala, Mexico, Brazil and Belize. The dried mature but unripe berries, berry oleoresin, berry oil and leaf oil are the products of commercial importance obtained from *P. dioica* and they find varied uses in the food, medicine and perfume industries. Among the pimentos from various geographical locations, Jamaican pimentos are considered to be of high quality because of their flavour, appearance and size and receive a premium price in the market (Table 9.2).

The major importing countries are the USA (Table 9.3), Germany, the UK, Finland, Sweden and Canada. Leaf oil is mainly exported to the USA and the UK. Pimento is generally classified with capsicum in the import statistics of most countries and hence analysis of the market situation is difficult.

9.2 Chemical composition

9.2.1 Berry

The dried, mature but not ripe, berries are the pimento spice used in commerce. Pimento is also sold as ground spice. Berries conforming to international standards should be between 6.5 and 9.5 mm in diameter, medium to dark brown in colour, with an uneven surface and with a pleasant odour, characteristic of the spice and with approximately 13 fruits/g. The dried berry contains aromatic steam volatile oil, fixed (fatty) oil, resin, protein, starch, pigments, minerals, vitamins (Table 9.4), etc. The constituents present in the oil influence the quality and aroma of the spice. The phenolic compounds eugenol and isoeugenol and the sesquiterpene hydrocarbon, β-caryophyllene are the major compounds present in allspice (Table 9.5). Several other compounds have been identified in allspice, which are present in lesser quantities (Table 9.6). The geographical variation, cultivar differences, stage

Table 9.2 Average price of allspice in New York

Country	Year	Price (dollars/pound)
Guatemala/Honduras	1997	0.961
	1998	1.041
	1999	1.920
	2000	2.452
Jamaica	1997	1.180
	1998	1.353
	1999	2.268
	2000	3.579
Mexico	1997	0.583
	1998	1.071
	1999	1.912
	2000	2.360

Source: http://www.fas.usda.gov/htp/tropical/2001/03-01/spcavg.pdf.

Table 9.3 Imports of allspice by the USA

Country	1999		2000	
	Quantity (kg)	Value (dollars)	Quantity (kg)	Value (dollars)
China	99850	126658	94320	69458
Guatemala	185349	540039	269339	1077571
Honduras	424028	1044247	297831	1137345
India	167379	118132	62809	62136
Jamaica	367384	1218489	359881	1789828
Lebanon	750	3000	0	0
Mexico	80849	201311	387081	1205363
Pakistan	13230	31832	28592	39483
Portugal	5000	2955	0	0
Spain	12668	52486	19800	13766
Taiwan	1081	3400	0	0
Thailand	0	0	4830	16325
Turkey	1326	2323	2852	4808
Other	39529	91470	40164	145499
Total	1398423	3436342	1567499	5561582

Source: http://www.fas.usda.gov/htp/tropical/2001/03-01/tropic.htm.

Table 9.4 Nutrient composition of allspice (per 100 g)

Composition	Quantity
Proximates	
Water	8.5 g
Food energy	262.6 kcal
Carbohydrates	72.1 g
Protein	6.1 g
Fat	8.7 g
Dietary fibre	21.6 g
Ash	4.6 g
Minerals	
Calcium	660.6 mg
Iron	7.1 mg
Magnesium	134.1 mg
Phosphorus	113.3 mg
Potassium	77.0 mg
Sodium	77.0 mg
Zinc	1.0 mg
Copper	0.6 mg
Manganese	2.9 mg
Vitamins	
Vitamin C	39.2 mg
Thiamin B1	0.1 mg
Riboflavin B2	0.1 mg
Niacin	2.9 mg
Vitamin B6	0.3 mg
Folate	36.0 μg
Vitamin E	1.0 mg

Source: http://ndb.nal.usda.gov/ndb/foods/show/220?qlookup=allspice&fg=&format=&man=&lfacet=&max=25&new=1

Table 9.5 Constituents identified in allspice extracts (ppm) using different extraction procedures

Compound	CO_2 extracts				
	150 bar/50 °C	350 bar/50 °C	350 bar/70 °C	SDE	DDE
α-Pinene	40	60	39	50	46
β-Pinene	39	55	37	56	54
Myrcene	38	48	37	79	72
(*e*)-β-Ocimene	23	29	23	48	46
α-Thujene	23	31	21	31	27
Sabinene	24	36	24	26	45
δ-3-Carene	55	74	52	102	95
α-Phellandrene	107	138	101	188	138
Limonene + β-phellandrene	138	188	119	298	233
p-Cymene	85	111	79	193	171
α-Terpinene	16	19	13	38	11
γ-Terpinene	87	111	83	183	150
Terpinolene	146	199	136	261	170
1,8-Cineole	272	355	249	472	403
Linalool	32	43	30	48	37
Terpinen-4-ol	110	160	107	198	123
p-Cymen-8-ol	21	31	22	41	20
α-Terpineol	47	70	47	90	44
Trans-*p*-Menth-2-en-1-ol- + *cis*-*p*-menth-2-en-1-ol	16	21	15	31	15
β-Caryophyllene	1749	2534	1595	1915	1838
α-Humulene	423	610	380	452	414
α-Selinene	267	383	236	262	237
β-Selinene	173	243	153	173	161
δ-Cadinene	210	307	188	216	186
β-Elemene	105	150	95	113	113
Allo-aromadendrene	81	118	73	83	82
Germacrene *d*	82	121	77	43	77
Spathulenol	42	54	39	47	34
Caryophyllene oxide + viridiflorol	187	225	147	168	142
Humulene oxide ii	39	55	35	47	34
t-Cadinol + *t*-muurolol	76	103	66	79	55
α-Muurolol	29	38	25	29	21
α-Cadinol	60	90	56	78	51
Selin-11-en-4-ol	131	170	113	120	78
Caryophylla-2(12),6(7)-dien-5-ol	30	37	25	28	29
Eugenol	18176	29976	18178	22240	11135
Methyl eugenol	1822	2670	1661	2025	1424
Chavicol	57	73	58	60	25
Myristicin	33	44	26	31	23
Elemicin	13	19	12	15	10

SDE: simultaneous distillation and extraction using diethyl ether. DDE: direct diethyl ether extract.
Source: Lawrence (1999).

of maturity, etc. also influence the quality of the berry. The quality of the berries from Jamaica is superior to that of berries from other islands and is preferred for trade. Prolonged storage of allspice is detrimental to both oil content and flavour of the spice.

Table 9.6 Minor compounds in allspice berries

Camphene (3 ppm)	*cis*-sabinene hydrate (2 ppm)
(*Z*)-β-ocimene (1 ppm)	Linalool oxide-furanoid (1 ppm)
α-*p*-Dimethylstyrene (1 ppm)	β-phellandren-6-ol (11 ppm)
δ-Elemene (1 ppm)	*trans*-piperitol (1 ppm)
α-Cubebene (10 ppm)	*cis*-piperitol (3 ppm)
α-Ylangene (6 ppm)	Hexanal (<1 ppm)
α-Copaene (35 ppm)	Benzaldehyde (<1 ppm)
β-Cubebene (1 ppm)	Cinnamaldehyde (1–10 ppm)
α-gurjunene (43 ppm)	Vanillin (1–10 ppm)
α-Bulnesene (27 ppm)	Methyl salicylate (3 ppm)
Aromadendrene (31 ppm)	Guaiacol (<1 ppm)
Selina-4,11-diene (35 ppm)	4-vinylguaiacol† (1 ppm)
γ-Muurolene (57 ppm)	Methyl chavicol (6 ppm)
Ar-curcumene (10 ppm)	Safrole (5 ppm)
Zingiberene (25 ppm)	(*E*)-isoeugenol (1 ppm)
α-Muurolene (42 ppm)	Methyl (*E*)-isoeugenol (1 ppm)
Germacrene a (11 ppm)	6-methyloxyeugenol (1–10 ppm)
β-Bisabolene (4 ppm)	Palustrol (1 ppm)
cis-Calamene (10 ppm)	Caryophyll-5-en-12-ol† (1 ppm)
β-sesquiphellandrene (5 ppm)	Isocaryophyllene oxide (1–10 ppm)
Cadina-4,11-diene (11 ppm)	Salvial-4(14)-en-1-one (1 ppm)
α-Cadinene (11 ppm)	Globulol† (12 ppm)
cis-Calacorene (3 ppm)	Humulene oxide (4 ppm)
trans-Calacorene (1 ppm)	Ledol† (1–10 ppm)
Camphor (1 ppm)	Eudesmol* (1–10 ppm)
Ascaridole* (3 ppm)	Selineol*† (1–10 ppm)
Carvone (11 ppm)	Eudesmol* (1–10 ppm)
Geranial (<1 ppm)	Epi-cubenol (21 ppm)
Linalyl acetate (3 ppm)	Caryophylla-2(12),6(13)-dien-5-ol (12 ppm)
α-Terpinyl acetate (10 ppm)	Isospathulenol (7 ppm)
Neryl acetate (2 ppm)	Cubenol† (1–10 ppm)
Geranyl acetate (6 ppm)	*trans*-sabinene hydrate (2 ppm)

* Correct isomer not identified; †Tentative identification.
Source: Lawrence (1999).

9.2.2 Berry oil

Extraction of berry oil can be carried out by different methods. Berry oil is generally obtained by hydrodistillation or steam distillation of dried immature berries. When supercritical CO_2 extraction techniques are employed for extraction of berry oil, the oil obtained is of superior quality and flavour, compared with steam-distilled or hydrodistilled oil. The compositions of berry oils extracted by steam distillation, hydrodistillation and supercritical CO_2 extraction techniques are compared in Table 9.7 (Garcia-Fajardo *et al.*, 1997). The berry oils extracted by supercritical CO_2 method and steam distillation have been characterized based on their physico-chemical properties (Table 9.8).

The yield of berry oil ranges from 3.0–4.5 %. The oil is yellow to brownish yellow with a warm spicy sweet odour and fresh and sweet top-note, and is placed in the warm, sweet spicy group (Arctander, 1960). About 60 constituents have

Table 9.7 Percentage composition of a steam-distilled oil, a hydrodistilled oil and a supercritical CO_2-extract of Mexican allspice

Compound	Steam distilled oil	Hydrodistilled oil	Supercritical CO extract
α-Pinene	trace	0.1	trace
β-Pinene	trace	0.2	trace
Sabinene	0.3	0.3	0.2
Myrcene	17.7	16.5	6.0
δ-3-Carene	trace	trace	–
α-Terpinene	trace	0.1	trace
p-Cymene	0.2	trace	trace
Limonene	0.7	trace	trace
1,8-Cineole	1.9	4.1	1.3
(*Z*)-β-ocimene	trace	1.2	0.9
γ-Terpinene	1.1	0.2	trace
Terpineolene	trace	0.6	0.4
Linalool	0.4	trace	trace
Terpinen-4-ol	0.3	0.5	0.3
Methyl salicylate	trace	trace	–
α-Terpineol	0.7	0.7	0.4
Eugenol	17.3	8.3	14.9
Methyl eugenol	48.3	62.7	67.9
β-Caryophyllene	6.2	2.7	5.2
α-Humulene	1.1	0.2	0.2
γ-Cadinene	0.6	0.1	0.2
β-Selinene	trace	trace	trace
α-Selinene	0.4	trace	trace
δ-Cadinene	trace	trace	trace

Source: Lawrence (1999).

Table 9.8 Physicochemical comparison of liquid CO_2-extracted and steam-distilled allspice berry oils

	Extraction procedure	
	Supercritical CO_2	Steam distillation
Specific gravity at 20°C	0.98 to 1.03	1.027 to 1.048
Refractive index at 20°C	1.505 to 1.525	1.525 to 1.54
Optical rotation at 20°C	–5 to 0	–5 to 0
Solubility in 70 % v/v ethanol at 20°C	1 to 2	1 to 2
Total phenols v/v, minimum	75 %	65 %

Source: Charalambous (1994).

been detected, including phenols, monoterpene hydrocarbons, oxygenated hydrocarbons, sesquiterpene hydrocarbons and oxygenated sesquiterpenes, and about 34 constituents were reported in steam-distilled berry oil using gas chromatography (Nabney and Robinson, 1972). The oil from green berries is similar in composition to that from dried berries, but has a higher monoterpene content (Ashurst *et al.*,

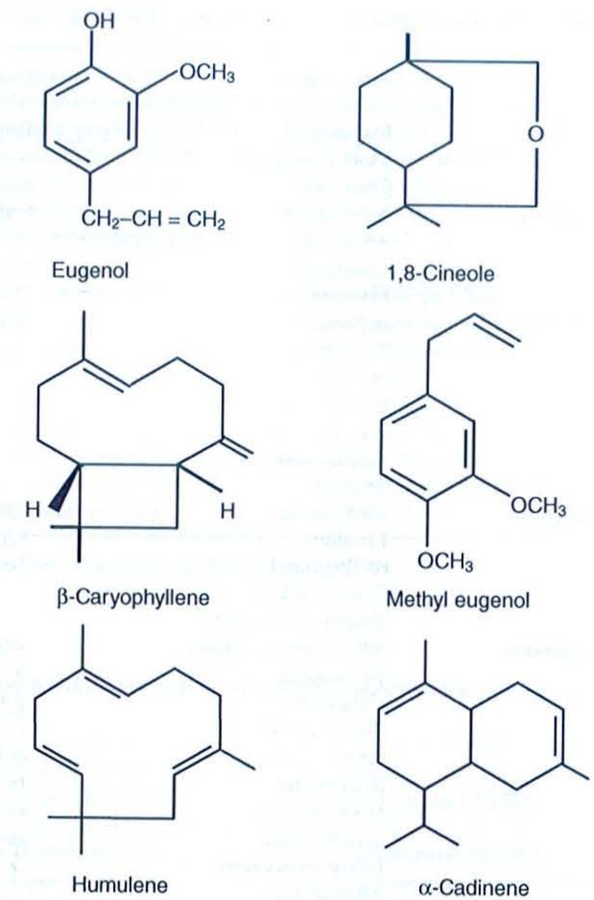

Fig. 9.1 Structures of some of the compounds in allspice.

1973). The principal components are usually eugenol, methyl eugenol, β-caryophyllene, humulene, terpinen-4-ol and 4,5-cineole (Fig. 9.1) (Tables 9.9, 9.10 and 9.11) (Nabney and Robinson, 1972; Purseglove *et al.*, 1981, Lawrence; 1999).

The main constituents affecting taste and flavour are the abundance and ratio of 1,8-cineole (Fig. 9.1) and α-phellandrene. Allspice contains various essential oils (Pino *et al.*, 1989), phenolic acids (Schulz and Herrmann, 1980), flavanoids (Vosgen *et al.*, 1980), catechins and phenyl propanoids (Kikuzaki *et al.*, 1999). The flavonol content of allspice is low and consists mainly of quercetin glycosides (Vosgen *et al.*, 1980). Three new galloylglucosides, (4*S*)-α-terpineol 8-*o*-β-D-(6-*o*-galloyl) glucopyranoside; (4*R*)-α-terpineol 8-*o*-β-D-(6-*o*-galloyl) glucopyranoside and 3-(4-hydroxy-3-methoxyphenyl) propane-1, 2-diol 2-*o*-β-D-(6-*o*-galloyl) glucopyranoside were isolated from berries of *P. dioica* (from Jamaica) together with three known compounds, gallic acid, pimentol and eugenol 4-*o*-β-D-(6-*o*galloyl) glucopyranoside (Kikuzaki *et al.*, 2000).

Allspice berry oil extracted by supercritical CO_2 extraction is light red brown with the full sweetness and fresh natural odour and flavour of the freshly ground

Table 9.9 Constituents identified in Jamaican allspice berry and leaf oils

	Berry oil	Leaf oil
Phenolics	Eugenol	Eugenol
	Methyl eugenol	Methyl eugenol
	Chavicol	Isoeugenol
Monoterpene hydrocarbons	Δ-3-Carene	Limonene
	p-Cymene	*cis*-β-Ocimene
	Limonene	*trans*-β-Ocimene
	Myrcene	α-Pinene
	α-Pinene	α-Phellandrene
	β-Pinene	Sabinene
	α-Phellandrene	γ-Terpinene
	α-Terpinene	Terpinolene
	γ-Terpinene	
	Terpinolene	
	Thujene	
Oxygenated monoterpenes	1,8-Cineole	1,8-Cineole
	Linalool	Linalool
	α-Terpineol	Terpinen-4-ol
	Terpinen-4-ol	
	Terpinen-4,8-oxide	
Sesquiterpene hydrocarbons	Alloaromadendrene	Alloaromadendrene
	γ-Cadinene	δ-Cadinene
	Calamene	β-Caryophyllene
	β-Caryophyllene	α-Copaene
	Ar-curcumene	α-Gurgunene
	β-Elemene	α-Humulene
	α-Humulene	α-Muurolene
	β-Humulene	α-Selinene
	Isocaryophyllene	
	γ-Muurolene	
	α-Selinene	
	β-Selinene	
Oxygenated sesquiterpenes	β-Caryophyllene alcohol	
	Caryophyllene oxide	
	Caryophyllene aldehyde	
	Humulene epoxide ii	

Source: Purseglove *et al.* (1981).

spice. The sensory character of the pimento berry oil obtained by steam distillation and liquid CO_2 extraction is represented in Fig 9.2 (Charalambous, 1994).

The initial impact of the liquid CO_2 extracted oil is sweet, spicy with a distinctly heavy fruity and floral dianthus character. After 6 hours the profile becomes warmer, more fruity and peppery, less phenolic and spicy. These notes are still prominent after 24 hours and continue for several days. The initial profile of steam distilled oil, although strong, is more phenolic, medicinal and less fruity. After 6 hours the profile becomes warmer with increased fruitiness but not attaining the richness of fruit notes of the CO_2 extract. The floral character is hardly noticeable at any stage of evaporation. All these notes are still prominent after 24 hours (Charalambous, 1994).

Table 9.10 Chemical composition of allspice berry oil

Eugenol (80.1 %)	α-Gurjunene (0.1 %)
Methyl eugenol (5.0 %)	Linalool (0.1 %)
β-Caryophyllene (4.5 %)	Terpinolene (0.1 %)
α-Muurolene (1.1 %)	(*E*)-β-Ocimene (0.1 %)
α-Selinene (1.1 %)	Globulol (0.1 %)
Ledene (0.8 %)	γ-Terpinene (0.1 %)
Allo-aromadendrene (0.7 %)	δ-3-Carene (0.1 %)
Calamenene (0.3 %)	*p*-Cymen-8-ol (0.1 %)
p-Cymene (0.3 %)	Copaene (unknown isomer) (0.1 %)
10-α-Cadinol (0.2 %)	α, *p*-Dimethylstyrene (0.1 %)
Methyl chavicol (0.2 %)	Limonene (0.1 %)
Spathulenol (0.2 %)	α-Pinene (0.1 %)
δ-Cadinene (0.2 %)	α-Thujene (0.1 %)
γ-Cadinene (0.2 %)	α-Phellandrene trace
1,8-cineole (0.2 %)	2-methylbutyl acetate trace
Myrcene (0.2 %)	α-Terpinene trace

Source: Guzman and Siemonsma (1999).

Table 9.11 Chemical composition of allspice berry oil from Cuba

Eugenol (87.0 %)	β-Selinene (0.2 %)
1,8-Cineole (3.3 %)	γ-Terpinene (0.2 %)
β-Caryophyllene (2.5 %)	α-Terpineol (0.2 %)
α-Humulene (1.6 %)	Calamenene (0.1 %)
p-Cymene (0.7 %)	Caryophyllene oxide (0.1 %)
Terpinen-4-ol (0.5 %)	α-Copaene (0.1 %)
Terpinolene (0.5 %)	γ-Muurolene (0.1 %)
δ-Cadinene (0.4 %)	β-Phellandrene (0.1 %)
Guaiene (unknown isomer) (0.4 %)	β-Pinene (0.1 %)
Limonene (0.4 %)	α-Terpinene (0.1 %)
α-Phellandrene (0.4 %)	γ-Cardinene (0.1 %)
Camphene (0.2 %)	α, *p*-Dimethylstyrene (0.1 %)
β-Elemene (0.2 %)	Humulene oxide (0.1 %)
Myrcene (0.2 %)	
α-Pinene (0.2 %)	Total 100 %

Source: Guzman and Siemonsma (1999).

9.2.3 Oleoresin

Oleoresin is prepared by extraction of the crushed spice with organic solvents followed by evaporation of the solvent. The composition of the oleoresin depends upon the raw materials and the solvents used for extraction of oleoresin. The oleoresin is a brownish to dark green oily liquid and two grades are normally available, based on the volatile oil content namely, 40–50 and 60–66 ml per 100 g. A US specification requires a minimum of 60 ml per 100 g.

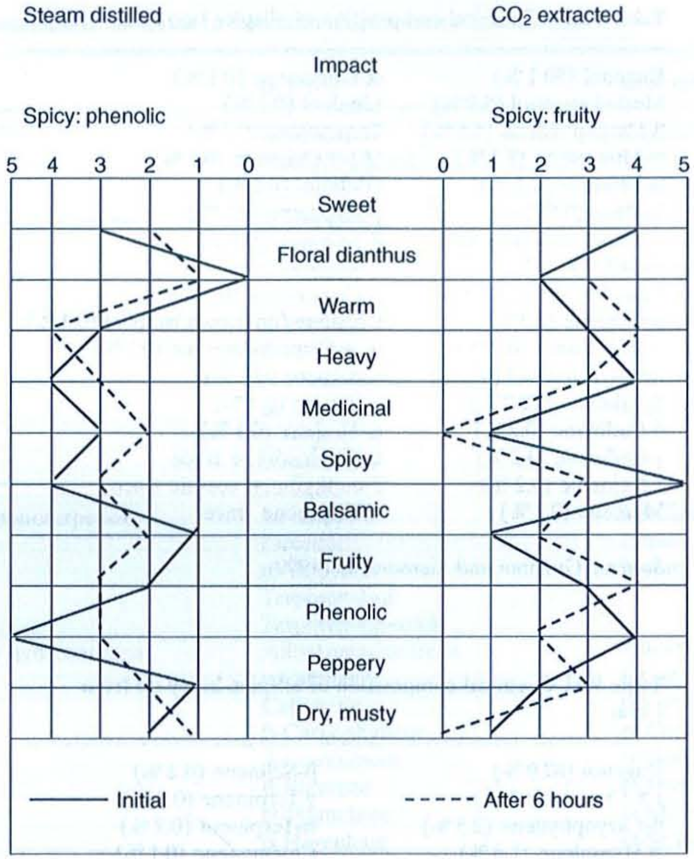

Fig. 9.2 Comparative odour profiles of steam-distilled and CO_2-extracted pimento berry oil. *Source*: Charalambous (1994).

Table 9.12 Leaf oil composition of allspice extracted by supercritical CO_2

Methyl chavicol (0.31 %)	α-Muurolene (0.05 %)
Thymol (1.82 %)	Calamenene* + γ-Cadinene (0.05 %)
Carvacrol (1.08 %)	Caryophyllene oxide (0.07 %)
Eugenol (93.87 %)	*t*-Cadinol (0.17 %)
β-Caryophyllene (1.79 %)	α-Cadinol (0.17 %)
α-Humulene (0.35 %)	α-Amorphene (0.37 %)

* Correct isomer not identified.
Source: Lawrence (1999).

A small quantity is sufficient to get the required flavour and aroma in food. Kollmannsberger and Nitz (1993) compared extracts using supercritical CO_2 extraction at various pressures and temperatures (150 bar and 350 bar at 50 °C, 350 bar at 70 °C) with there using direct diethyl ether extract and simultaneous distillation

Table 9.13 Chemical composition of leaf oil of allspice of Cuban origin

α-Pinene (0.56 %)	γ-Terpinene (0.56 %)
Myrcene (0.19 %)	Terpinolene (1.38 %)
α-Phellandrene (1.12 %)	Menthol (0.56 %)
p-Cymene (1.87 %)	Methyl chavicol (0.09 %)
1,8-Cineole (14.50 %)	Carvone (0.10 %)
Limonene (0.10 %)	Thymol (1.00 %)
Carvacrol (1.00 %)	δ-Cadinene (5.49 %)
Eugenol (28.04 %)	Cadina-1,4-diene (0.49 %)
β-Caryophyllene (1.00 %)	α-Calacorene (1.23 %)
α-Humulene (10.12 %)	Caryophyllene oxide (2.69 %)
Allo-aromadendrene (2.13 %)	α-Eudesmol (0.52 %)
α-Amorphene (2.77 %)	β-Eudesmol (0.82 %)
α-Muurolene (1.76 %)	*t*-Cadinol (6.64 %)
Calamenene* + γ-Cadinene (11.12 %)	α-Cadinol (4.94 %)

* Correct isomer not identified.
Source: Lawrence (1999).

and extraction of pimento berries. Supercritical CO_2 extracted at 350 bar pressure and 50 °C temperature was found to be the best (Table 9.5).

9.2.4 Leaf oil

Pimento leaf oil is produced by distilling fresh or dry leaves. Oil can also be extracted using supercritical extraction, and the extraction procedure with CO_2 has been described (Falconieri *et al.* 2010). Leaves used for distillation may be fresh, withered or dried and stored for 2 or 3 months prior to distilling. Yields from dried and fresh leaves are 0.5–3.0 % and 0.3–1.25 %, respectively. Oliveira *et al.* (2009) also recently reported that the yield of essential oils in leaves and fruits varied from 0.97 to 1.41 % and the major component was eugenol. The leaf oil is a brownish yellow liquid with dry–woody, warm–spicy aromatic odour.

The main composition of the leaf oil of allspice is eugenol. Eugenol content of leaf oil (65–96 %) is somewhat higher than that in berry oil (Pino and Rosado, 1996; Pino *et al.* 1997). The major compounds of the leaf essential oil from Jamaica sample was identified as eugenol (76.02 %), methyl eugenol (7.14 %) and β-caryophyllene (6.47 %) (Jirovetz *et al.*, 2007). Leaf oil composition of allspice extracted using the supercritical CO_2 method is given in Table 9.12. The chemical composition of the oil is also influenced by the geographical origin of the spice (Tables 9.9 and 9.13) (Pino *et al.*, 1997).

Variation was observed in the yield and composition of leaf oil from fruiting female and non-fruiting male trees. Oil yields in male pimento trees (2.13 %) were lower than those in female trees (2.67 %). The contents of eugenol ($p < 0.01$), myrcene, α -phellandrene, γ-terpinene, terpinolene and α-thujene ($p < 0.005$) were significantly different in the female and male trees. Non-fruiting and fruiting trees contained the same volatile components with different relative abundances. Monoterpenoid profles could be used for the early prediction of the berry-bearing ability of pimento trees. (Minott and Brown, 2007).

9.3 Cultivation

9.3.1 Propagation

Seeds

Allspice is traditionally propagated through seeds, but vegetative propagation is also adopted to get true to type plants. High-yielding trees that fruit regularly and have well formed fruit bunches are selected as mother trees. Fresh ripe fruits from such high-yielding trees are collected and seeds are extracted from the ripe fruits after soaking them overnight in water and rubbing them in a sieve to remove the pericarp. Allspice seeds lose their viability soon after harvest and hence seeds are planted immediately after extraction. If seeds are to be transported or kept for a few days, it is advisable not to extract the seeds from the fruits. It is reported that the viability of the seeds can be maintained at 50 % for nine weeks by storing them at 21–30 °C (Devadas and Manomohandas, 1988).

Seeds are sown in beds of 15–20 cm height, 1 m width and convenient length made of loose soil–sand mixture over which a layer of sand (about 5–8 cm thick) is spread. Seeds are sown at 2–3 cm spacing and depth of about 2 cm. The seed bed has to be protected from direct sunlight. If only a small quantity of seeds is available for sowing, they can be sown directly in polybags filled with a soil–sand–cowdung mixture and kept in the shade.

The beds may be mulched with dried leaves or straw to hasten germination. Watering should be done regularly. Germination commences in about 9–10 days and continues over a month. All the mulching on the seed bed must be removed as the seeds start germinating. The seedlings are transplanted into polythene bags (25 cm × 15 cm) containing a mixture of soil, sand and well-decomposed cowdung (3:3:1) at the three- to four-leaf stage. The seedlings are ready for transplanting to the field at 9–10 months old, when they are 25–40 cm high.

Vegetative propagation

Allspice is polygamodioecious, and it is difficult to identify the functional male and female trees until they flower. Hence clonal propagation is necessary to obtain uniformly high-yielding trees. Cuttings of allspice could be rooted in 7–8 months with hormonal application. Air layering of softwood and semi-hardwood shoots with hormone application (indolebutyric acid 4000 ppm + naphthalene acetic acid 4000 ppm) aided in rooting of allspice (Rema *et al.* 1997, 2008). Studies on air layering in Maharashtra indicated that rooting is a slow process, taking 18–28 months and that January is the best season for rooting (Haldanker *et al.*, 1995). Propagation of allspice through chip budding is also possible although the percentage of success is low (30 %). Approach grafting of allspice was reported with 90 % success in Jamaica (Chapman, 1965). Approach grafting on its own rootstock was also successful in India.

9.3.2 Climate and soil

The natural habitat of allspice in Jamaica is limestone forest. Although allspice is planted on a wide range of soils, a well-drained, fertile, loam limestone soil with a pH of 6–8 suits the crop best. Pimento grows well in semi-tropical lowland forests with a mean temperature of 18–24 °C, a low of 15 °C and a maximum of 32 °C. Allspice flourishes well up to 1000 m above sea level. An annual rainfall of 150–170 cm evenly spread throughout the year is desirable, but allspice grows well with a rainfall of 120–250 cm.

9.3.3 Planting and after-care

The spacing recommended for allspice is 6 m × 6 m. Pits of about 60 cm deep and 30 cm wide are dug and are filled with topsoil to which well-rotted manure or compost are incorporated. Although permanent shade trees are not considered necessary for allspice, they may be required in very exposed conditions. Transplanting should be done at the beginning of the rainy season. For vegetatively propagated trees, one male tree should be planted for every ten females for adequate pollination. When trees are grown for leaves to produce oil, the sex of the tree is not important.

The base of the young seedlings should be kept free of weeds. After 3–4 years of growth, slashing once or twice annually around the tree would be sufficient. The larger weeds in the plantation may be controlled from time to time by slashing. The branches cut from the trees during harvesting can be used as mulch. Allspice has to be irrigated until it is 2 or 3 years old. Generally, fully grown trees of allspice are not irrigated. However, in a severe summer, irrigating trees on alternate days at 10 l/tree is recommended. Very little is known about the manurial requirements of pimento. As the tree is found mainly on soils derived from limestone, it is generally assumed that it is a lime-demanding plant and there are indications that the crop requires a soil relatively high in potash (Ward, 1961). A fertilizer dose of 20 g N, 18 g P_2O_5 and 50 g K_2O/tree in the first year after planting is progressively increased to 300:250:750/year for a grown tree of 15 years or more. The fertilizers are to be applied in two equal doses (May and September), in shallow trenches dug around the plant about 1.0–1.5 m away from the tree. The Department of Agriculture, Jamaica, recommends 1 kg of 10:10:10 or 15:15:15 NPK mixture applied during February and September at 0.4 kg/tree/application. Young plantations can be intercropped for 1–3 years with crops such as banana or any other low-growing plants such as pulses.

9.3.4 Harvesting, processing and storage

The clonally propagated plants start flowering in 3 years and seedlings in 5–6 years under well-managed conditions. Seedling trees take 18–20 years to come into full bearing. The berries are harvested when fully grown, but still green, about 3–4 months after flowering. The time and extent of flowering are affected by the local conditions and climate, particularly the time of onset of the spring rains, so that the time of harvesting varies between seasons and places. It normally occurs from August–September in Jamaica, July–August in Guatemala and Honduras and

September–October in Mexico. Allspice does not produce fruits in the plains. Spraying paclobutrazol was reported to induce flowering in allspice and further spraying of indoleacetic acid + benzylaminopurine induces fruit set in allspice (Krishnamoorthy *et al.*, 1995).

A healthy, well-managed tree would produce on average 10 kg green berries/tree annually after 10 years. Allspice gives a good crop once every 3 years. Care must be given while harvesting berries to be used as spice as the quality of the berry is assessed mainly on appearance, colour, flavour and essential oil content. Berries for distillation require less care.

The harvested berries are taken to the drying shed and left in heaps up to 5 days to ferment. Berries are then spread in drying yards and turned frequently to ensure uniform drying. It takes about 5–10 days for drying (12–14 % moisture content) depending upon the weather. Well-dried fruits should be brownish black in colour and rattle when a handful is shaken. About 55–65 kg berries is obtained from 100 kg green. The dried berries are cleaned and stored in a clean dry place. In Guatemala, berries are blanched in boiling water for 10 minutes. This process reduces contamination and produces an attractive colour in the dried spice. Because of frequent shifting of the berries in and out of the sheds during rainy days, many berries break and, hence, mechanical drying is preferred. Artificial drying is adopted in places where the berries mature during the rainy season. Solar energy dryers and many other simple dryers using firewood and forced air dryers are available for drying allspice. A small-scale unit of hot air drying can dry 250 kg (550 lb) of green pimento in 8 hours (Breag *et al.*, 1973). A maximum temperature of 75 °C is recommended for obtaining good-quality allspice without any loss in essential oil content. Microbial contamination is also reported to be minimum in artificial drying.

The dried fruits should be stored in poly-lined corrugated cardboard containers or in air-tight containers and kept in a cool, dry area with a maximum temperature of 21 °C and maximum humidity of 70 %. Excessive heat volatilizes and dissipates aromatic essential oils and high humidity tends to cake them. Dried fruits should be stored off the floor and away from outside walls to minimize the chances of dampness. The product has to be kept away from heavy aromatic materials. The essential oil is stored in sealed opaque containers. The industry standard has recommended a shelf-life of 24 months.

9.3.5 Diseases

Leaf rust

The most serious disease of pimento in Jamaica is the leaf rust, caused by *Puccinia psidii* Wint. The young leaves, shoots, inflorescence and young fruits are covered by a bright yellow powdery mass of urediospores in the infested trees. Severe infection results in defoliation of the young leaves, with successive attacks culminating in the death of the tree. Leaf rust has also been reported in Florida. The variety of *P. psidii* reported on allspice in Jamaica is different from that found in south Florida (Marlatt and Kimbrough, 1979). The disease is severe during late winter and early spring on flushes of new growth in Florida. The symptoms are observed on both upper and lower surfaces of the leaves. Mature leaves bear circular, brown, necrotic lesions covered with urediospores.

Die back

The tree is also affected by die back or canker, caused by *Ceratocystis fimbriata* Ell. and Halst. The disease is usually localized and spreads to other parts of the tree. Bark canker and dark streaking of the wood with drying of the leaves is observed in infected trees. When primary infection occurs below a fork in the tree, death occurs within few months. The disease can be controlled by pruning and removal of all dead and infected branches and application of 1 % Bordeaux mixture.

Leaf rot

A leaf rot disease caused by *Cylindrocladium quinqueseptatum* was reported in India. The disease is severe during June–September. The disease can be controlled by a prophylactic spraying of 1 % Bordeaux mixture in June (Anandaraj and Sarma, 1992).

9.3.6 Pests

Borer

The larvae of red borer *Zeuzera coffeae*, Nietner (*Cossidae lepidoptera*) damage allspice by tunnelling into the collar region (Abraham and Skaria, 1995). The branches wither and wilt. Swabbing the main stem with a suspension of 0.25 % carbaryl was found to be effective against the pest.

Tea mosquito

The tea mosquito *Helopeltis antonii* has been reported to attack allspice in Kerala (Devasahayam *et al.*, 1986). The bug causes necrotic lesions on young shoots of allspice. The pest can be controlled by spraying quinalphos 0.05 % on tender flushes.

Leaf-damaging pests

Caterpillars of the bagworm *Oeceticus abboti* and related species feed on young leaves and shoots of allspice. Young leaves are also damaged by whiteflies, *Aleyrodidae*, and the redbanded thrips, *Selenothrips rubrocintus*. Adults of the weevils *Prepodes* spp. and *Pachnaeus* spp. also feed on leaves and their larvae damage roots. Scale insects, soft and hard, are frequently present on trees but normally do little damage (Purseglove *et al.*, 1981).

Fruit fly

The fruit fly *Anastrepha suspensa* is reported to occur on allspice in Jamaica (Van Whervin, 1974) and cause damage to the berries.

9.4 Main uses of allspice

Whole spice, ground spice, berry oil, leaf oil and oleoresin are the major products obtained from pimento. The Mayans used allspice to embalm and preserve the bodies of their leaders. Allspice was more popular in the early twentieth century than it is today. It is reported that during World War II a shortage of the spice occurred in Europe and its popularity never recovered (Tainter and Grenis, 1993).

The major use of allspice is in the food industry (65–70 %). A small quantity is used for domestic purpose (5–10 %), for production of pimento berry oil (20–25 %), for extraction of oleoresin (1–2 %) and in the pharmaceutical and perfume industries.

9.4.1 Uses in the food industry

Allspice is mostly used in western cooking and is less suitable for eastern cooking. It is most used in British, American and German cooking. The dried mature fruits are mainly used as a flavouring and curing agent in processed meats and bakery products and as a flavouring ingredient for domestic and culinary purposes. Whole fruits are preferred in prepared soups, gravies and sauces. Whole ripe berries are an essential component of the local Jamaican drink *Pimento dram* and as an ingredient of the liqueurs Chartreuse and Benedictine.

Ground spice

The major use of allspice in the ground form is for flavouring processed meats, baking products, fruit cakes, pies, desserts, pickles, sauces, salads, vegetables, soups, fish, poultry, sausages, meats, marinades, mulled wine and preserves. For domestic culinary use, pimento is often mixed with other ground spices.

Oleoresin

Oleoresin is also used in the meat processing and canning industries in the same way as ground spice is used. Allspice oleoresin is prepared in very small quantities and has not become a substitute for ground spice in the food industry. However, it has an advantage over ground spice in that it avoids the risk of bacterial contamination and its strength and quality are more consistent.

Essential oil

The berry oil contains all the odour principles of the ground spice and oleoresin but lacks some of the flavour principles. Essential oils from leaf oil and berry oil are used as a flavouring agent in meat products and confectioneries. The maximum permitted level of berry oil in food products is about 0.025 %.

9.4.2 Deodorizing effect

The major function of allspice is to flavour food, but it has a sub-function of deodorizing or masking unpleasant odours. The concentration of methyl mercaptan is a major cause of bad breath, and it was observed that allspice has a deodorizing rate of 61 % (deodorizing rate is the percentage of methyl mercaptan (500 ng) captured by methanol extract).

9.4.3 Uses in traditional medicine

Allspice is not only valued as a spice to add flavour to food but has medicinal, antimicrobial, insecticidal, nematicidal, antioxidant and deodorizing properties. The powdered fruit of allspice is used in traditional medicine to treat flatulence,

dyspepsia, diarrhoea and as a remedy for depression, nervous exhaustion, tension, neuralgia and stress. In small doses it can also help to cure rheumatism, arthritis, stiffness, chills, congested coughs, bronchitis, neuralgia and rheumatism. It has anaesthetic, analgesic, antioxidant, antiseptic, carminative, muscle relaxant, rubefacient, stimulant and purgative properties (Rema and Krishnamoorthy, 1989). It is also useful for oral hygiene and in cases of halitosis. An aqueous suspension of allspice is reported to have anti-ulcer and cytoprotective activity by protecting gastric mucosa against indomethacin and various other necrotizing agents in rats (Rehaily *et al.*, 2002).

9.5 Functional properties

9.5.1 Antioxidant properties

Antioxidants help to preserve foods from oxidation and deterioration and to increase their shelf-life. They can also be used as a natural preservative. Spices and herbs are recognized as sources of natural antioxidants (Mariutti *et al.*, 2008) and thus play an important role in the chemoprevention of diseases resulting from lipid peroxidation (Chung *et al.*, 1997). Allspice has a strong hydroxyl radical-scavenging activity (Nakatani, 2000). The berries of *P. dioica*, showed strong antioxidant activity and radical-scavenging activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical (Miyajima *et al.*, 2004).

The antioxidant properties of *P. dioica* essential leaf oil were assayed by study of the capacity to counteract DPPH (2,2-diphenyl-1-picrylhydrazyl), hydroxyl (OH) and superoxide radicals (Jirovetz *et al.*, 2007). The ethyl acetate-soluble part of the berries showed strong antioxidant activity and radical-scavenging activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical. From the ethyl acetate-soluble part, two new compounds, 5-galloyloxy-3,4-dihydroxypentanoic acid and 5-(5-carboxymethyl-2-oxocyclopentyl)-3*Z*-pentenyl 6-*O*-galloyl-β-D-glucoside, were isolated together with 11 known polyphenols. Quercetin and its glycosides showed remarkable activity for scavenging DPPH radical and inhibiting peroxidation of liposome. Two new compounds also exhibited strong DPPH radical-scavenging activity and inhibitory effect on the peroxidation of liposome as myricetin (Oliveira *et al.*, 2009).

The antioxidant properties of the essential oil were compared to those of the synthetic antioxidant propyl gallate and it was observed that the free radical-scavenging activity of the essential oil was concentration dependent and was higher than that of the synthetic antioxidant propyl gallate (Feng Xue *et al.*, 2010). Allspice had high concentration of antioxidants (i.e. > 75 mmol/100 g)(Dragland *et al.*, 2003).

Compounds that markedly inhibit the formation of malondialdehyde from 2-deoxyribose and the hydroxylation of benzoate with the hydroxyl radical were isolated from methanol extracts of allspice. These compounds were identified as pimentol and had a strong antioxidant activity as hydroxyl radical scavengers at 2.0 μm (Oya *et al.*, 1997). A phenylpropanoid, threo-3-chloro-1-(4-hydroxyl-3-methoxyphenyl) propane-1,2-diol, isolated from berries of *P. dioica* inhibited auto-oxidation of linoleic acid in a water–alcohol system (Kikuzaki *et al.*, 1999). Allspice was screened for superoxide anion radical (O_2^{-}) scavenging activity and it was observed that allspice decreased the yield of DMPO-O_2^-. The mechanism of O_2^- scavenging activity was by the inhibition of the formation of O_2 (Yun *et al.*, 2003).

Four new phenolic lycosides, (2-hydroxy-3-methoxy-5-allyl) phenyl β-D-(6-*O*-*E*-sinapoyl) glucopyranoside (1), (1'*R*,5'*R*)-5-(5-carboxymethyl-2-oxocyclopentyl)-3*Z*-pentenyl β-D-(6-galloyl) glucopyranoside (2), (*S*)-α-terpinyl [α-L-(2-*O*-galloyl) arabinofuranosyl]-(1->6)-β-D-glucopyranoside (3) and (*R*)-α-terpinyl [α-L-(2-*O*-galloyl) arabinofuranosyl]-(1->6)-β-D-glucopyranoside (4), were isolated from the berries of *P. dioica* together with eight known flavonoids. All the four glycosides showed radical-scavenging activity against 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical. (Kikuzaki *et al.*, 2008). The effect of different allspice extracts (ethanol, chloroform, diethylether, benzene and hexane) on the stability of rapeseed oil was examined. The ethanol extract exhibited a remarkable antioxidant effect and the antioxidant effectiveness of various extracts was in the order ethanol extract > chloroform extract > diethylether extract > benzene extract > hexane extract (Vinh *et al.*, 2000).

9.5.2 Toxicity

Allspice oil should only be used in low dilutions since it is found to irritate the mucous membrane, owing to the presence of eugenol in allspice oil. It is also reported to cause dermal irritation. At low doses, it is non-toxic, non-irritant, non-sensitizing and nonphototoxic.

9.5.3 Fungicide

Essential oil of allspice is reported to have antifungicidal activity (Farina *et al.*, 2007). The antifungal potential of extracts of allspice was tested *in vitro* against the field fungus (*Fusarium oxysporum*) and six storage fungi (*Aspergillus candidus, A. versicolor, Penicillium aurantiogriseum, P. brevicompactum, P. citrinum* and *P. griseofulvum*) and *in situ* against the initial mycoflora of wheat grains after harvest (mainly *Fusarium* spp., *Alternaria* spp. and *Cladosporium* spp.). Allspice suppressed the growth of all the above fungus *in vitro* (Scholz *et al.*, 1999). Essential oil inhibited the activity of *A. niger, Candida albicans, C. blanki, C. cylindracea, C. glabrata, C. krusei, C. tropicalis* and *Saccharomyces cerevisiae.* The minimum inhibitory concentration range for essential oil of allspice was 0.31–1.25 $\mu L\ mL^{-1}$ (Kamble and Patil, 2008).

9.5.4 Bactericide

Allspice had a strong bactericidal effect against *Yersinia enterocolitica* (Bara and Vanetti, 1995). The minimum inhibitory concentrations (%) of hexane extracts of allspice for several pathogenic bacteria are given in Table 9.14. (Hirasa and Takemasa, 1998). A study testing thymol (thyme and oregano), eugenol (clove, pimento and cinnamon), menthol and anethole (anise and fennel) on three pathogenic bacteria, *Salmonella typhimurium, Staphylococcus aureus* and *Vibrio parahaemolyticus*, showed that all these spice components inhibited the bacteria to different extents. Eugenol was more active than thymol, which was more active than anethole. Eugenol is also sporostatic to *Bacillus subtilis* at 0.05–0.06 % level (Tainter and Grenis, 1993).

Table 9.14 Minimum inhibitory concentration of hexane extracts of allspice for pathogenic bacteria

Bacteria	Minimum inhibitory concentration (%)
Escherichia coli	10
Salmonella sp.	>10
Staphylococcus aureus	10
Bacillus cereus	10
Camphytobacter	10

Source: Hirasa and Takemasa (1998).

Allspice was also reported to suppress *Escherichia coli, S. enterica* and *Listeria monocytogenes* (Friedman *et al.*, 2002). Essential oil was found to reduce the intracellular and extracellular verocytotoxin produced by *E. coli* (Takemasa *et al.*, 2009). Edible films made from fruits or vegetables containing essential oils can be used commercially to protect food against contamination by pathogenic bacteria. Apple-based films with allspice were active against three foodborne pathogens namely, *E. coli, S. enterica*, and *L. monocytogenes* both by direct contact with the bacteria and indirectly by vapours emanating from the films (Du *et al.*, 2009).

9.5.5 Insecticide

Allspice is reported to have insecticidal properties. The effect of 103 plant powders on the mortality and emergence of adults of *Sitophilus zeamais* and *Zabrotes subfasciatus* was evaluated in the laboratory. Powdered allspice caused > 20 % mortality of *S. zeamais*. Allspice oils at all concentrations inhibited egg hatch of *Corcyra cephalonica* compared with the control (Bhargava and Meena, 2001). Essential oil of allspice had very strong insecticidal activities against the Japanese termite, *Reticulitermes speratus* Kolbe (Seo *et al.*, 2009).

9.5.6 Nematicide

The nematicidal activity of the essential oil of allspice (*P. dioica* L. Merr.) leaves and its major constituent eugenol was tested against *Meloidogyne incognita.* The essential oil and eugenol exhibited promising nematicidal activity at 660 μg/ml (Leela and Ramana, 2000). Essential oil of allspice was effective against the pine wood nematode *Bursaphelenchus xylophilus* (Park *et al.*, 2007).

9.5.7 Perfumery

The oil is used in perfumery, notably for oriental fragrances. It is used as a fragrance component in perfumes, cosmetics, soaps and aftershaves.

9.6 Quality issues and adulteration

9.6.1 Specifications

Cleanliness, safety issues (microbes and moisture levels) and economic parameters aroma, flavour and granulation) are the main quality aspects dealing with spice. The cleanliness specifications have been set out in laws such as Food and Drug Administration Defect Action Levels (FDADALs) (USA) or in trade practices such as the American Spice Trade Association (ASTA), European Spices Association (ESA), etc.

Description

As per the ISO specifications, allspice is described as the dried, fully mature but unripe, whole berry of *P. dioica* (L.) Merrill, 6.5–9.5 mm in diameter, a dark brown colour, the surface somewhat rough and bearing a small annulus formed by the remains of the our sepals of the calyx. Allspice may also be in the pure ground form.

Odour and taste

The odour and taste of pimento, either whole or ground, shall be fresh, aromatic and pungent. It shall be free from any foreign taste or odour, including rancidity or mustiness.

Freedom from moulds, insects, etc.

Allspice, whole or ground, shall be free from living insects and moulds and shall be practically free from dead insects, insect fragments and rodent contamination visible to the naked eye with such magnification as may be necessary in any particular case. In case of dispute, the contamination of ground pimento shall be determined by the method specified in ISO 1208 (ISO, 1982).

Extraneous matter

All that does not belong to the fruits of allspice and all other extraneous matter of animal, vegetable and mineral origin shall be considered as extraneous matter. Broken berries are not considered as extraneous matter. The total percentage of extraneous matter in whole dried allspice shall not be more than 1 % (m/m) when determined by the method described in ISO 927 (ISO, 2009).

Product and cleanliness specification

The standard specifications of various countries for berries, leaf oils and berry oil of allspice are given in (Tables 9.15–9.20) and the cleanliness specifications are given in Tables 9.21 and 9.22.

9.6.2 Sampling

Sampling shall be carried out in accordance with the method specified in ISO 948 (ISO, 1980).

Table 9.15 Chemical requirements of allspice

Characteristics	Requirement		Methods of test
	Whole	Ground	
Moisture content, % (m/m), max.	12	12	ISO 939
Total ash, % (m/m) on dry basis, max.	4.5	4.5	ISO 928
Acid insoluble ash, % (m/m) on dry basis, max.	0.4	0.4	ISO 930
Volatile oil, % (ml/100 g) on dry basis, min.			ISO 6571
Group A, more than	3	2	
Group B, min.	2	1	
max.	3	2	
Non-volatile ether extract, % (m/m) on dry basis, max.	–	8.5	ISO 1108
Crude fibre, % (m/m) on dry basis, max.	–	27.5	ISO 5498

Source: Purseglove *et al.* (1981).

Table 9.16 US government standard specifications for allspice

Moisture, not more than	10 %
Total ash, not more than	5 %
Acid-insoluble ash, not more than	0.3 %
Volatile oil, ml per 100 g, not less than	3
Sieve test	
US standard sieve size	No. 25
Percentage required to pass through, not less than	95

Source: Purseglove *et al.* (1981).

Table 9.17 Canadian government standard specifications for allspice

Total ash, %, not more than	6.0
Ash insoluble in HCl, %, not more than	0.4
Crude fibre, %, not more than	25
Quercitannic acid, calculated from the total oxygenabsorbed by the aqueous extract, % not less than	8

Source: Purseglove *et al.* (1981).

Table 9.18 European Spice Association (ESA) product specification for allspice

Product	Ash % w/w (max.)	Acid insoluble ash % w (max.)	Moisture % w/w (max.)	Volatile oil % v/w (min.)
Jamaica	5 (ESA)	0.4 (ISO)	12 (ISO)	3.5 (ISO)
Other origins	5 (ESA)	1 (ESA)	12 (ISO)	2 (ESA)

ISO = International Organization for Standardization.
Source: Sivadasan and Kurup (1998).

Table 9.19 British Standards Institute specifications for allspice

	Berry oil	Leaf oil
Apparent density, g/ml at 20 °C	1.025 to 1.045	1.037 to 1.050
Optical rotation at 20 °C	0 °C to –5 °C	–
Refractive index at 20 °C	1.526 to 1.536	1.531 to 1.536
Phenolic* % volume, minimum	65	80
Solubility in ethanol at 20 °C (70 % v/v)	2 volumes	2 volumes

* Determined by absorption with 5 % KOH.
Source: Purseglove *et al.* (1981).

Table 9.20 Essential oil association of the USA specification

	Berry oil EOA No. 255	Leaf oil EOA No. 73
Specific gravity at 25 °C	1.018 to 1.048	1.018 to 1.048
Optical rotation at 20 °C	0° to –4 °C	–0°30' to –2°
Refractive index at 20 °C	1.527 to 1.540	1.5319 to 1.5360
Phenols*, % by volume, minimum.	65	50 to 91
Solubility in 70 % alcohol at 25 °C	2 volumes	2 volumes

* Determined by absorption with 1N KOH.
Source: Purseglove *et al.* (1981).

Table 9.21 American Spice Trade Association (ASTA) cleanliness specifications for allspice

Total extraneous matter, determined by sifting and by hand picking, % by weight	0.5
Mammalian excreta, mg/lb	2.0
Other excreta, mg/lb	5.0
Whole insects, dead (by count) per lb	2.0
Insect-bored or otherwise defiled berries, % by weight	1.0
Mouldy berries, % by weight	2.0

Source: Sivadasan and Kurup (1998).

Table 9.22 Dutch regulations regarding cleanliness for allspice

Ash content (max %)	6.0
Sand content (max %)	1.5

Source: Sivadasan and Kurup (1998).

9.6.3 Packing

Allspice, whole or ground, shall be packed in clean and sound containers made of a material that does not affect the product but that protects it from the increase or loss of moisture and volatile matter. The packaging shall also comply with any national legislation relating to environmental protection.

Table 9.23 Maximum permissible limits of trace metals in allspice

Metal	Concentration (in ppm)
Aluminium	73
Arsenic	0
Barium	4.8
Beryllium	0.037
Bismuth	0
Boron	8.6
Cadmium	0
Copper	5.1
Lead	0
Lithium	0
Magnesium	1300
Manganese	11
Molybdenum	0.4
Nickel	0.57
Selenium	0.16
Silicon	18
Strontium	2.4
Tin	7.8
Titanium	1.6
Zinc	9.4

Source: Sivadasan and Kurup (1998).

9.6.4 Marking

The following particulars shall be marked directly on each package or on label attached to the package: name of the product (type: whole or ground) and trade name; name and address of the producer or packer and trademark, if any; code or batch number; net mass; grade; producing country; any other information requested by the purchaser, such as the year of harvest and date of packing (if known).

9.6.5 Pesticide residues

The limits for pesticide residue prescribed for other agricultural products are generally followed for spices. Maximum permitted limits of trace metals in allspice are given in Table 9.23.

9.6.6 Adulteration

Ground pimento is sometimes adulterated with powdered clove stem or with the aromatic berries of the Mexican tree *Myrtus tobasco*, known as 'pimienta de tobasco'. The powdered berries of the aromatic shrub *Lindera benzoin* (called wild allspice) has a strong spicy flavour in bark and berries and is used as a substitute for allspice by the Americans. A mixture of pimento leaf oil and clove stem and leaf oils can serve as a relatively inexpensive substitute for berry oil. Pimento berry oil is sometimes adulterated with eugenol from cheaper sources. Samples are also considered adulterated or of poor quality for trade if they contain an average of 30 or more insect fragments per 10 g, or an average of one or more rodent hairs per 10 g or an average of 5 % or more mouldy berries by weight.

9.7 References

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