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Medicinal and Aromatic Plant Series, No.2



KARAPINCHA

(*Murraya koenigii*)

Information Services Centre
Industrial Technology Institute
(Successor to CISIR)
Colombo, Sri Lanka

NA 228

Medicinal and Aromatic Plant Series, No. 2



Murraya koenigii
- a literature survey -

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Murraya koenigii

1.0 INTRODUCTION

The curry leaf plant, *Murraya koenigii* belongs to the family Rutaceae. It is native to India and Sri Lanka and is commonly cultivated in home gardens. The name ' Curry Leaf ' was derived from the wide use of its leaves as a food flavour in curry preparation. The flavour enhancing qualities of this spice harmonize with eastern cooking and especially suited to curries, vegetable, fish and meat dishes, soups and curry powder blends. The leaves retain its flavour and aroma even after drying and hence they are sold both in the fresh and dried states. It is also used in native ayurvedic preparations and as a home remedy for dysentery.

2.0 BOTANY ^{15,37,48,54,81,86}

2.1 TAXONOMY

Family : Rutaceae

Genus : *Murraya*

Species : *koenigii*

Botanical names

Murraya koenigii Spreng; *Bergera koenigii* Linn.

Other names

Sinhala : Karapincha; Karrypincha

English : Curry- leaf tree

Tamil : Karuvembu, Karuveppilai, Kattuveppilai

Sanskrit : Alakarhaya, Chardighna, Girinimba, Kasdarya, Kalasaka, Krishnanimba, Mahanimba, Maharishta, Nimbapatra, Priyasala, Raman, Sauranimba, Shuklasara, Surabhi. Surabnimba, Varatikta

2.2 PLANT DESCRIPTION

A pretty, aromatic more or less deciduous shrub or a small tree, up to 6 m in height and 15-40 cm in diameter. The wood is hard, close-grained, pale yellowish-brown and durable. Leaves are compound, alternate, imparipinnate. Usually hairy-petioled leaves range from 10-45 cm or more in length and are composed of 9 to 25 alternate, short stemmed, light green leaflets.

Leaves are symmetrical, elliptic, ovate, lanceolate or somewhat rhomboid, blunt-pointed and minutely toothed, 2.5 to 5 cm long, 1 to 2.5 cm wide; finely hairy on the underside and strongly, muskily aromatic of distinctive bitter acid flavour. Flowers borne on broad, hairy stalked, erect, corymbose panicles, are regular, bi-sexual, white, sweetly fragrant, sepals 5, small neatly distinct, triangular, subacute, pubescent. Fruits are ovoid or nearly round, with a small point at the apex; thin skinned; turn from green to red and finally black when ripe and contain mucilaginous pulp around 1 or 2 small white seeds.

3.0 HABITAT³⁷

It is widespread in Sri Lanka, India and Andaman Islands. It is very common in the low country dry zone but rather rare in Anuradhapura, Polonnaruwa, Maturata and Badulla. It also grows in Thailand, Kampuchea, Laos and Vietnam.

4.0 AGRONOMY^{22,26,52,81,85}

4.1 SOIL AND CLIMATE

The tree is hardy and flourishes up to an elevation of 600 m in Sri Lanka and up to 1,500 m in the Himalayas. It grows well in almost any type of soil if there is good drainage.

4.2 PROPAGATION

Propagation is by root suckers or air-layers, but is usually by seeds, which are best germinated in partial shade in nurseries. The seedlings are transplanted when 1 year old. They are planted in the field at a tree to tree spacings of 3 to 5 meters.

4.3 FERTILIZER

Two year old curry leaf bushes require 150g N/plant/year for optimum production of the leaves with a basal dressing of 25g each of P and K. It has been found in an experiment that three year old plants at 5m spacing gives a highest annual yield, when treated with 200g N + 100g P₂O₅ + 100g K₂O per plant. But the pruning levels have no significant effect on the leaf yield.

4.4 HARVESTING

The first harvesting of leaves can be taken about 6 months after sowing and altogether two pickings are possible during the first year, while in the subsequent years, three normal pickings can be done. In harvesting, leaves are plucked individually, or the terminal cluster of foliage complete with the silky, purplish new shoots are clipped off. Care should be taken not to allow plucking so as to expose the branches and trunk to sunburn.

4.5 DISEASES^{52,59}

The crop is relatively free from serious pests and diseases. Diseases that are sometimes observed are as follows:

White sap rot - A fungal disease by *Fomes pectinatus*

Collar rot in seedlings - A fungal disease by *Rhizoctonia solani*

Leaf spots and leaf blight - This disease causes brown to black water soaked spots on the leaf by *Xanthomonas murrayayae*.

5.0 CHEMISTRY OF PLANT ^{1,5-7,9,10,13,18,22,26-28,36,48,50,53,55-57}

5.1 CHEMICAL CONSTITUENTS OF PLANT (Per 100g of edible portion)

Moisture	63.8g	Energy	108Kcal
Proteins	6.1g	Fat	1.0g
Carbohydrate	16.0-18.7g	Ca	810-830mg
P	570-600mg	Fe	3.1 -70mg
Thiamine	80mcg	Riboflavin	210mcg
Niacin	2.3mcg	Vitamin C	4mg
Total Nitrogen	1.15g	Total sugars	18.92%
Starch	14.60	Crude fibre	1.0-6.4g
Ash	13.06g	Acid insol. Ash	1.35g
Mineral matter	4.2g	Total oxalates	1.352g
Soluble oxalates	1.155%	Carotene	7,560mg (12,600 I.U)(Vit. A)

The leaves are a fair source of vitamin A and a rich source of calcium. Unfortunately the high concentration of oxalic acid reduces its nutritional availability.

The proximate composition of fresh curry leaves at 3 stages of maturity namely tender, medium and mature leaves indicates that the concentration of total N, crude protein, fat, total sugars, starch and crude fibre increases with age. But the concentration of volatile oil gradually decreases with maturity.

The curry leaf plant, has been studied extensively in the last two decades and more. It is known to be the richest source of carbozole alkaloids so far reported. More than 40 carbozole alkaloids have been isolated from it.

Carbozole alkaloids from *Murraya koenigii*

Alkaloid	Part of the plant
Bicyclomahanimbine	
Bicyclomahanibicine	stem wood
Bikoeniquinone A	root bark, stem bark
Bis-2-hydroxy-3-methyl carbozole	root bark, stem bark
Bismurrayaquinone A	root bark, stem bark
Bismahanine	root bark, stem bark
Curryanine	
Curryangine	
Cyclomahanimbine	
Girinimbine	leaves, fruits
Girinimbitol	stem bark

Glycozoline	root
1-Hydroxy -3-methyl carbozole	stem bark
2-Hydroxy -3-methyl carbozole	
Isomahanimbine	leaves, stem bark
Isomahanine	fruits
Isomurrayazoline	
Koenidine	leaves
Koeniline	root bark
Koenine	leaves
Koenimbine	leaves, fruits
Koenigicine	
Mahanimbicine	
Mahanimbine	fruits
Mahanimboline	root bark
dl-Mahanimbine	leaves, stem wood
Mahanimbiol	stem bark, stem wood
Mahanimbidine	stem wood
Mahanine	leaves, fruits
2-Methoxy-3-methyl carbazole	
2-Methoxy carbazole-3 methyl carboxylate	stem bark
3-Methyl carbazole	root
Mukoline	
Mukolidine	
Mukonal	stem bark
Mukoenine A	}
Mukoenine B	
Mukoenine C	
Mukoic acid	root bark, stem bark
Mukonidine	
Mukonicine	leaves
Murrayacine	
Murrayanine	stem wood
(±) Murrayazoline	stem bark
d, l - Murrayazolidine	stem bark, fruits
Murrayafoline F	root bark, stem bark
Murrayazolinol	stem bark
Murrayanol	fruit
Murrayenol	root
Murrayagetin	root

Other than the above alkaloids, the following amino acids were also isolated from dried leaves of *Murraya koenigii*:

Asparagine	γ - aminobutyric acid	Glycine
Phenylalanine	Serine	Leucine
Aspartic acid	Isoleucine	Glutamic acid
Traces of ornithine	Threonine	Lysine
Alanine	Arginine	Proline
Histidine	Tyrosine	Tryptophan

3(1',1'-dimethyl allyl) xanthylentin
 Scopoletin
 Marmesin-1''-O- β -D-galactophranoside
 Marmesin-1''-O-rutinoside

Furocoumarins from seeds:

Isoheraclenin	0.00064%
Isoimperatorin	0.00208%
Oxypeucedonin	0.00028%
Isopimpinellin	0.00074%
Bergapten	0.00118%

Scopolin
 Osthol
 Umbelliferone
 Epilupeol

The following lipids were isolated from the seeds:

Oleic acid	33.6%
Linoleic acid	39.4%
Palmitic acid	17.9%
Stearic acid	8.6%

5.2 CHEMICAL COMPOSITION OF OIL OF LEAVES

Steam distillation of fresh leaves under a pressure of 6.33 kg/cm² yield about 2.6% of a volatile oil which may find use as a fixative for heavy type of soap perfume. Distillation at ordinary pressure gives very poor yields of oil, while distillation with superheated steam at 220 °C yields a dark coloured, foul smelling oil.

Rectified curry leaf oil is deep yellow in colour with a spicy odour and pungent clove- like taste.

Characteristics of essential oil:

Sp. Gravity 25 °C	0.9748
n^{25}_D	1.5021
$[\alpha]^{25}_D$	+ 4.8°
Sap. Value	5.2
Sap value after acetylation	54.6
Acid value	3.8

Sol. in 80% alcohol with slight opalescence.

The intense characteristic aroma of the leaves, is probably due entirely to terpene hydrocarbons. Presumably the major components, β -caryophyllene, β -gurjunene, β -elemene, and β -phellandrene are the most important aroma constituents. However, β -gurjunene and β -thujene may be particular contributors to the unique aromas as they are much less common than most of the other terpene hydrocarbons in other species.

Analysis of the essential oil obtained by steam distillation of the leaves by capillary GC and GC/MS using Supelcowax 10 and SPB-1 fused silica capillary columns revealed that sixty two components were present, with β -phellandrene, α -pinene, β -caryophyllene and terpinen-4-ol as the major constituents.

Compound	Kovats indices		Percentage ^a
	Supelcowax 10	SPB-1	
α -thujene	1025		1.6
α -pinene	1030	927	17.5
Camphene	1068	953	0.2
β -pinene	1120	979	3.7
Sabinene	1130	972	4.1
m- or p-xylene	1142		t
Ethylbenzene		844	(t)
Myrcene	1156	984	2.3
α -phellandrene	1160	1003	4.8
α -terpinene	1177	1014	2.8
Limonene	1188	1030	5.1
β -phellandrene	1208	1024	24.4
(Z)-2-hexenal		820	(t)
γ -terpinene	1231	1055	4.9
(E)- β -ocimene	1258		1.8
p-cymene	1268	1018	1.0
Terpinolene	1274	1078	1.1

1,2,4-Trimethylbenzene ^b		1285	t
2-Octanone	1304		t
(Z)-3-Hexenyl acetate	1310		t
(Z)-2-Pentenol	1317		t
3-Methylbut-2-en-1-ol	1325		t
6-Methylhept-5-en-2-one	1340		t
Hexanol	1357		t
(Z)-3-Hexenol	1390	847	0.2
2-Nonanone	1397		t
1-Methyl-2(2-propenyl)			
-benzene	1446		0.1
Cis-linalool oxide	1453		t
(Z)-3-Hexenyl butanoate		1464	t
Trans-sabinene hydrate	1480	1073	0.4
Trans-linalool oxide	1482		0.1
2-Furancarboxaldehyde	1486	800	0.1
α -Copaene	1489	1370	t
(E,E)-2,4-Heptadienal	1497		t
2-Acetylfuran	1505		t
Benzaldehyde	1520		t
Linalool	1554	1085	0.6
Cis-sabinene hydrate	1571	1133	0.5
Bornyl acetate	1591	1278	t
β -elemene		1387	(0.2)
Lavandulyl acetate ^b	1594	1276	0.9
β -caryophyllene	1598	1440	7.3
Terpinen-4-ol	1612	1165	6.1
Aromadendrene		1459	(0.1)
α - humulene	1675	1472	0.6
α - terpineol	1718	1172	1.6
β - selinene	1743	1502	t
α - selinene	1748	1510	1.1
Neryl acetate		1343	(t)
δ - Cadinene	1760	1525	0.6
Naphthalene	1762		0.4
Methyl salicylate	1804		t
Cis-sabinol	1820		t
p-cymene-8-ol	1875		t

Cis-jasmone ^b	1973	1377	0.1
Nerolidol	2053	1550	0.1
Globulol	2085	1633	0.1
Spathulenol	2121	1565	0.2
p-vinylguaicol	2155		0.1
Carvacrol	2162		t
3-Ethyl-4-methyl -maleimide ^b	2197		t
2,3-Dihydrobenzofuran	2314	1187	0.1

^a percentage of total FID area obtained on Supelcowax 10 column; values within parentheses obtained on SPB-1 column

^b tentatively identified

t = trace (<0.05%)

5.3 VOLATILE CONSTITUENTS OF FLOWERS

Flowers too possess very strong aromas. Analysis of the volatile constituents of *Murraya koenigii* fresh flowers by capillary GC and GC/MS yielded the following compounds.

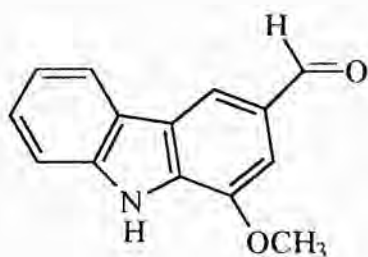
Compound	Kovats index	Area percentage
α - pinene	1030	1.6
Hexanal	1090	t
β - pinene	1120	0.1
Sabinene	1128	0.1
Isoamyl acetate	1140	0.1
α - phellandrene	1167	0.6
Limonene	1190	0.5
β - phellandrene	1208	3.7
(E)-2-Hexanal	1218	t
(Z)- β -Ocimene*	1234	0.6
(E)- β -Ocimene	1253	18.0
p-cymene	1268	0.1
Hexanol	1357	t
Nonanal	1387	0.1
Trans-linalool oxide	1449	0.2
δ - elemene*	1465	0.2
Linalool	1554	8.0

β - caryophyllene	1598	24.2
α - humulene	1675	5.1
Lavandulol*	1698	0.2
α - terpineol	1713	0.7
Germacrene D*	1721	0.6
β - selinene	1729	1.1
α - selinene	1737	2.2
Bicyclgermacrene*	1745	2.6
δ - cadinene	1760	4.4
Germacrene B*	1812	0.2
Benzyl alcohol	1878	0.9
cis-jasmone	1939	0.3
Caryophyllene oxide*	1965	0.7
(E)-Nerolidol	2042	0.9
Globulol	2064	0.3
Elemol*	2073	0.1
T-cadinol*	2161	0.3
T-muurolool*	2176	0.1
Ethyl palmitate	2241	3.5
Ethyl-palmitoleate	2285	0.2
Ethyl heptadecanoate	2319	0.2
(E,E)-farnesol*	2353	0.9
Ethyl oleate	2488	0.7
Ethyl linoleate	2556	1.3
Ethyl linolenate	2607	0.5
Phytol	2619	0.5
2-Phenylethyl benzoate	2697	2.1
Palmitic acid	2880	3.2
Palmitoleic acid	2951	0.4
Oleic acid		0.6
Linoleic acid		1.0

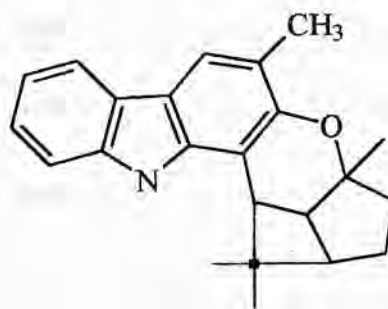
* terpenoids not found in analysis of leaf oil

The fruit is edible. It yields 0.76% of a yellow volatile oil with neroli-like odour and pepper-like taste, accompanied by an agreeable sensation of coolness on the tongue. Characteristics of this oil are as follows:

Specific gravity (13 ⁰ C)	0.872
n _D	1.487
[α] _D	-27.24°
b.p	173-74 ⁰ C



Murrayanine



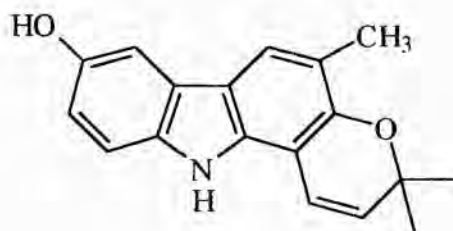
Bicyclomahanimbine



Mukonidine



Koenigine



Koenine



Curryangine



Figure 1. Carbozole alkaloids from *Murraya koenigii*

6.0 PROCESSING OF CURRY LEAVES ^{2,52,81}

Fresh curry leaves are used to a large extent in culinary practices in Sri Lanka and India. Flavour retention is poor in the dried leaves. Various methods of drying the leaves have been tested. Sun-drying (33 °C) is fairly fast but it creates a very dark material. Other methods, drying by cross-flow (55 – 58 °C ; air velocity 1.5 – 2.0 m/sec.) and through flow (55 – 58 °C; air velocity 3.5 – 4.5 m/sec.) give leaves a light to medium green colour. The vacuum shelf (50 °C) method gave a better green colour, in the product.

Organoleptic analysis of the powdered leaves showed that though the characteristic leaf flavour was lacking, the product resulting from cross-flow drying and oven drying were superior. In the case of oil, distilled oil from cross flow dried as well as oven dried samples were more or less similar to oil from fresh curry leaves.

6.1 PREPARATION OF CURRY LEAVES POWDER :

To prepare a powder, the fresh leaves are blanched in a hot solution of 0.2% Potassium metabisulphite, 0.1% Sodium bicarbonate, and 0.1% Magnesium oxide for 3min. Then they are oven-dried at 60 - 65 °C for 3 – 3.5h to achieve a moisture content of about 3 to 4%.

7.0 BIOLOGY AND HEATH ASPECTS ^{19,32,58,73,74,79,82}

7.1 BIOLOGICAL ACTIVITY

Principal biologically active components:

β - caryophyllene	β - gurjunene	A-selinene
β - phellandrene	limonene	2-methylbutanal
β -thujoene	β -pinene	α -phellandrene
t- β -ocinune	p-cymene	α -copaene
α -cobebene	γ - cadinene	β - bisalolene
mahanimbine	cyclomahanimbine	bicyclomahanimbine
mahanimbidine	curryanine	curryangine
mukonicine	isomahanimbine	koenimbine
koenigine	mahanine	koenine
mahanimbicine	bicyclomahanimbicine	koenigicine

An aqueous extract of the leaves given orally produced hypoglycaemia in normal and alloxan - induced diabetic dogs. Hypoglycaemia persisted for 13 days in normal animals whereas in diabetic animals it lasted for 8h after oral administration. Given intravenously (40mg/kg), the extract produced hypoglycaemia lasting 21h in normal dogs. It was found that crushed leaves of *Murraya koenigii* exhibited hypoglycaemic activity in fasting normal rabbits during the 1st hour itself with a dose level of 10g/kg. The same response was seen in glucose tolerance test studies in rabbits. Furthermore in human volunteers there was a peak fall in blood sugar at 50g dose level after 3h of medication.

Murraya koenigii showed strong toxicity against fungi *Pythium aphanidermatum* and *Pythium debaryanum*. The essential oils could control damping off of tomato by up to 67% in soil infected with *Pythium aphanidermatum* and by 71% in soil infected with *Pythium debaryanum*.

The ethanolic extract of the stem bark showed anti-inflammatory effect in carrageenan induced inflammation in rats (1g/kg inhibited ca.65.21 inflammation). Marmasin - 1"- O - β - D - galactopyranoside isolated from this extract showed moderate to appreciable activity against *Vibrio cholerae*, *Salmonella typhimurium*, *Klebsiella pneumoniae*, *Candida albicans*, *Aspergillus fumigatus* and *Tricophyton mentagrophytes*. Aqueous extract of the plant showed fungitoxic activity against ringworm causing fungi.

It has also been shown that *Murraya koenigii* which contains mahanine, isomahanine and murrayanol as active ingredients may be used in oral disinfectants against dental caries and periodontal disease. They are effective against *Streptococcus mutans* and *Porphyromonas gingivalis*.

Chloroform-soluble extract of the root bark displayed a significant *in vitro* cytotoxic activity against cultured KB cells, when it was tested according to standard protocols. It has been shown that girinimbine and mahanimbine are cytotoxic active constituents towards cultured KB cells. It was also found that the dichloromethane extract of the root bark, koenoline and murrayanine exhibited ED₅₀ values in KB cell-culture test system of 6.0 μ g/ml, 4.0 μ g/ml and 26 μ g/ml respectively.

An extract of *Murraya koenigii* containing carbozole alkaloids, 9-methoxy mahanimbicine and murrayanol are used as a microbicide in a variety of industries. The microbicide is safe to use, has strong activity, little odour and no colouring effect and therefore it is widely used in many industries. Bark and roots are recorded to have stimulant properties.

Aqueous extracts of leaves, when administered parenterally to female guinea pigs, not only raise the phagocytic index but also mobilize a greater number of leucocytes to take part in phagocytosis, but the effect does not last long.

7.2 ETHNOMEDICINE ^{14,18,27,37,42,55,64}

7.2.1 HOME REMEDIES

The five parts of the tree, the leaves, roots, bark, the stalk and flowers boiled or powdered together are used for any type of stomach disorder. The karapincha stems in cunjee form is used for any kind of dysentery. The green tender leaves and raw fruits are eaten raw for the cure of dysentery.

An infusion of the roasted leaves is used to stop vomiting. A decoction of leaves is sometimes given with bitters as a febrifuge and the leaves had been claimed to be used with mint in the form of chutney to check vomiting.

Crushed leaves are applied on bruises and skin eruptions. After boiling in milk, leaves are pounded and plastered on bruises and bites of venomous creatures. Crushed bark and roots are used similarly.

The root juice is taken to relieve pain in the area of kidneys. Leaves and stalk in decoction or boiled in ghee is recommended as a remedy in rheumatism, leprosy, epilepsy and cure of eye diseases. The boiled leaves are also given for hiccough and hoarseness. A decoction of the leaves is given with the addition of bitters in fevers.

In Central Vietnam, the leaves are put into water for bathing infants afflicted with mange. The Swahilis in East Africa burn the leaves as incense in the belief that the smoke will protect their sick children from evil spirits.

7.2.2 AYURVEDIC PREPARATIONS ^{4,27,64}

The leaves, bark and the root of the plant are used in indigenous medicine as a tonic, stomachic, stimulant, febrifuge, laxative and carminative. It has also been used as an anti-periodic, and many a time the powdered dry leaf mixed with honey and juice of betelnut is recommended in the Ayurvedic system of medicine.

Native Ayurvedic Preparations

In colic and diarrhoea :

Leaves of *Murraya koenigii*, fruits of *Terminalia chebula*, *Piper nigrum*, seeds of *Carum roxburghianum* and *Sodii chloridum* equal parts are fried well and made into a fine powder. Ingestion of powder with the addition of the oil of *Sesamum indicum* and boiled rice, is said to cure colic, puffiness of the stomach and phlegmatic diarrhoea.

In hiccough and hoarseness :

Leaves of *Murraya koenigii*, the root of *Clerodendron sephonanthus*, fruits of *Piper longum*, roots of *Solanum jacquinin*, fruits of *Vitis vinifera* (dried grapes), stem of *Tinospora cordifolia*,

dried root of *Zingiber officinale*, the root of *Casio sophora*, are weighed equally to total 56g and cut into small pieces and bruiced. 896 ml of water is added, boiled in a low fire till it reduces to 1/4 and strained. Taking this strained decoction in 112g doses twice a day morning and evening with the addition of honey is said to cure hoarseness hiccough and asthma and act as a tonic.

In constipation etc. - (Pancha churnaya)

The dried leaves of *Murraya koenigii* 28g the fruits of *Piper longum* 28g, the fruits of *Piper nigrum* 112g, dried roots of *Zingiber officinale* 140g. Sodi Chloridum (rock salt) 162g. All these ingredients are fried a little, in the fire and made into a fine powder and mixed with clarified butter. Taking this medicine 5 doses in about one and half to three dracham doses twice a day morning and night at meal hours with boiled rice is said to cure constipation, abdominal colic and increases the appetite.

7.3 COMMERCIAL PREPARATIONS OF KARAPINCHA

Product	Description	Uses
Karapincha – Garlic Capsules	Each capsule contains the equivalent of 8g of karapincha leaves, tender shoots and garlic. Dosage: 1-2 capsule per day.	It is effective in reducing serum cholesterol, LDL cholesterol and triglycerides.
Karapincha Herbal Tea	Dried and cut into small pieces and poured like tea.	It removes toxicity and is also fat reducing
Karapincha Kanda	Prepared by boiling raw rice and mixing with coconut milk and the juice of the karapincha leaves. Instant karapincha kanda is available in market.	As a part of the morning meal; has a high demand in Oman, Dubai, Japan, Sweden, UK, USA and Canada
Toothpaste	Contains CaCO ₃ 50%, glycerin 20%, carrageenan 0.50%, CM-Cellulose 1.0%, lauryl diethanolamide 1.0%, sucrose monolaurate 2.0%, odorant 1.0%, saccharine 0.10% and 0.20% <i>Murraya koenigii</i> leaf ethanolic extract with remainder water	

Other products ^{52.81}

Fruits are not generally recognized as edible. However, in India the firm-ripe fruits are harvested in the summer, steamed, washed, cooked passed through a pulper to remove seeds, and canned with or without the addition of sugar.

The flavour enhancing qualities of this spice harmonize with Sri Lankan and South Indian cooking especially suited to curries, vegetables, fish and meat dishes, soups, chutneys, curry powder blends etc. Curry leaf extractives are now available in water / oil soluble and emulsified forms.

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