PHYSICO CHEMICAL CHARACTERISTICS, VALUE ADDITION AND SHELF LIFE OF EVALUATION KARONDA (*Carissa carandas*)

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1. INTRODUCTION

Humans the world over have depended on wild-growing plants in their diets for hundreds of thousands of years and many people continue to rely on these species for livelihood. Numerous plant species provide food and nutritional support world over harvested foods in the form of roots, shoots, leaves, fruits and grains meet at least part of nutritional demands of many population.

Indian agriculture, passing through various revaluations has achieved unprecedented development. Production and productivity of many crops have increased manifold. But the challenges of malnutrition, income to farmers and threat of climate change continue, need immediate attention. In this context, wild, minor or underutilized crops appear to be the crop of future and need focused attention as it can meet nutritional needs besides sustaining the effect of climate change. India is endowed with a rich genetic diversity of underutilized fruits. The underutilized fruit crops of Indian origin like karonda, *bael(Aegle marmelos), jamun (Syzigium cumini), ker* (*Capparis deciduas)* and several others are directly interwoven in the socio-economic fabric of rural masses and especially of tribes dwelling in remote hot, arid and fragile ecosystems.

Even though some of the underutilized fruits possess superior sensory qualities, medicinal values and commercial exploitation potentials, they have remained confined either to natural wild, semi-wild or semi-domesticated conditions. Besides being important as potential horticulture species, these plants are store houses of genes for adaptation to hot and hardy climates, salt tolerance, disease tolerance and several essential nutritional values. In this regard, karonda - *Carissa* species- *C. carandas* L, syn. *C. congesta* Wight.; *C.spinarum* L. and *C. grandiflora* Bert. Ex A. DC is important fruit yielding plant. The common name of *C. carandus* are -karonda, karmada, karvanda; *C. spinarum* are –karaunda, kavali and *C. grandiflora* is called as natal plum. The plant belonging to family Apocynaceae and is note worthy for its multifaceted benefits.

Karonda is a very hardy and drought tolerant plant (Plate 1). It thrives well throughout the tropical and subtropical climates however heavy rainfall and waterlogged conditions are not suitable. Karonda is usually an evergreen deciduous small to big shrub, 2 to 4m tall a sprawling semi-vine shrub or medium-sized wild thorny shrub growing gregariously in the semi-arid regions, scrub forest habitats throughout India at an altitude of 300 to 1800 m. Several species of karonda such as *Carissa carandas* and *C. spinarum, C. grandiflora* have been identified. The species of *C. carandas* and *C. spinarum* are native to India but also are grown in Sri Lanka, Myanmar, Thailand and Peninsular Malaysia. *C. grandiflora* is native to South Africa (Malik *et. al.,* 2010). Genetic diversity of karonda is spread throughout India, main areas of variability exists in the states of Maharashtra, Karnataka, Bihar, West Bengal, Chhattisgarh, Orissa, Gujarat, Madhya Pradesh, Rajasthan and in Western Ghats and Aravali Hills. The karonda stem exudes white latex and the branches bear sharp spines. Flowers are white, small, measuring 3-5 cm in diameter. Flowering starts in the month of January-February and fruits mature in May-June. Fruits are generally harvested at immature stage for vegetable purpose, fully ripen fruits are consumed fresh or processed.

Karonda plant is a hardy, drought-tolerant plant that thrives well in a wide range of soils including saline and sodic. Karonda bushes can be grown for raising beautiful juvenile hedges the presence of auxiliary spines favour to be a very good bio-fence. The plant can also be grown as an ornamental plant owing to its beautiful cherry-like fruits. The leaves of the plant are easily biodegradable and enrich the soil contributing organic carbon and other mineral matter. Due to the presence of dense foliage, the evaporation rate from the soil underneath a karonda plantation is extremely slow and, therefore, suitable under moisture-stress conditions. The roots of the plant are heavily branched and make it suitable for stabilizing eroding slopes.

Karonda fruit also commonly called as karmada, karvanda, karunda, kavali and natal plum is one such fruit which needs to be promoted for cultivation and utilization as fresh fruit or in value added food products and also for the medicinal values associated with the plant parts. The fruit is a berry, which is formed in clusters of 3-10 fruits. The fruit is globose to broad ovoid in shape and contains many seeds.

Plate 1. Wild Karonda – plant, flowers, stages of fruit

Plate 2.Karonda Selection – plant , flowers, unripe and ripe fruits

Young fruits are pinkish white and become red to dark purple when ripe. Variation in fruit colour has been indicated from green, green with purple blush, white with pink blush and maroon, associated with maturity. Colour of ripe fruit varies from white, green, dark purple and pinkish red, depending on the genotype.

Recognizing the importance of karonda in the changing agricultural scenario, efforts are being made for collection of germplasm of karonda from different locations in various Indian research institutes. However, popularization of this species has not been undertaken, in spite of possessing promising horticultural traits such as bold fruits size with good amount of pulp, bright red colour at ripen stage and very good sour sweetish taste. (Malik *et. al*., 2010) Genotypic variations in plant type, fruit colour, size, shape, bearing, pulp colour, taste, number of seeds per fruit of karonda have been documented. Few selections based on location and qualities of fruits have been identified by different institutions of India (Plate 2). Some of the known selections are PK-3, PK-4, Pant Manohar, Pant Dudarshan and Pant Suvarna from Horticultural Research Station, G.B. Pant University of Agriculture and Technology, Pantnagar, Regional Station Patharchatta and two selections maroon colored and white pinkblush from Narendra Dev University Faizabad, have been identified.

Unripe fruits are very sour at maturity but sourish sweet when ripe. The fruit is a globose berry, oblong, broad-ovoid or round, 125 mm to 250 mm long. It has thin tough, green to purplish-red smooth, glossy skin turning dark-purple or nearly black when ripe. The unripe fruits are processed as pickles at household levels and ripe are consumed fresh. The unripe fruit harvested at maturity can be stored for 5 to 7 days at room temperature, but at ripe stage, it can be stored only up to two days. Although, recently value added commercial preparations are made for domestic use and for export by food processing companies, the plant has remained as underutilized species.

Ethno medically the fruits are used for curing anemia and as an astringent, antiscorbutic and as a remedy for biliousness. A leaf decoction is used against fever, diarrhea, and ear ache. The roots serve as a stomachic, vermifuge and remedy for itches and insect repellent. In traditional medicine the fruit is used to improve appetite, female libido and to remove worms from the intestinal tract. The fruits have anti-microbial and antifungal properties and its juice used to clean old wounds. The fruits possess analgesic anti- inflammatory properties.

Karonda has remained unexploited from a commercial point of view in spite of its usefulness to mankind and hardy nature to be grown preferably inferior lands. It's also rich source of essential vitamins and minerals required in human health (Manivasagan *et. al*., 2007). Although the fruits possessed excellent sensory parameters no efforts are being made for domestication and human selection. Being tolerant to biotic and abiotic stresses, these fruit species are reported to be ideal for growing in the disaster and drought prone areas (Mitra *et. al.,* 2006). Hence this fruit of Indian origin under the changing world trade scenario can be exploited on a commercial scale as a fruit for the processing industries. Therefore the present investigation was undertaken to explore the utilization and value addition potentials of karonda with the following objectives

i. Shelf life evaluation of unripe and ripe karonda fruits at ambient and refrigerated storage in polyethylene and paper bags
ii. To determine ascorbic acid and selected minerals in unripe and ripe karonda
iii. Standardization for value added products based on unripe and ripe karonda
iv. Storage quality evaluation of selected value added karonda products.

2. REVIEW OF LITERATURE

In nature there are thousands of plant species that could nourish the human kind. Hundreds of plants species have been domesticated but only few are being consumed commonly. These plant species which are grown wild or semi cultivated have remained as minor or underutilized plant species. A detailed review of minor fruits, physico-chemical characterisation and value addition potentials are presented in this chapter and a glimpse of such fruits depicted in Table 1.

2.1 Global scenario of minor fruits as edible fruits

Several studies are reported world over indicating the different minor fruits with potential uses for food purposes. Bajracharya (1980) suggested that edible wild fruits played significant role in nutrition of Nepalese, especially those in the hilly areas where wild fruits were only sources of edible fruits such as *lapsi, ainselus, kaphal, chutro, bayers, chiuri* and *painyar.*

A survey of four forest ranges for fruit yielding trees of Western Ghats of Uttara Kannada district of Karnataka, recorded 34 different fruit yielding trees (Anonymous, 1998). Similar existences of a wide range of underutilized fruits were also revealed in tropical and subtropical regions of India, which were either consumed fresh or after processing by (Pushpakumara *et. al*., 2000).

Reports of abundance of minor fruits being source of micronutrients in Africa were made by Mitra associates, (2006). Fruits such as jackfruit (*Artocarpus heterophyllus*), bael (*Aegle marmelos*), longan (*Dimocarpus longan*), rambutan (*Nephelium lappaccum*), jamun (*Syzygium cuminii*), ber (*Zizyphus muritiana*), durian (*Durio zibethinus*), carambola (*Averhoa carambola*), aonla (*Emblica officinalis*), karonda (*Carissa carandas*) and phalsa (*Grewia asiatica*) were reported to be source of vitamins and minerals. Minor fruits provided healthful substances particularly antioxidants in addition to calories and minerals Goldwin (2003)

Different geographical zones of Arunachal Pradesh were surveyed for wild edible plants by Angami and associates (2006). The results indicated 118 different plant species to be consumed by the local population as fruits, leaves, barks, flowers, tubers and stems. Fruits and leaves were used commonly. Species like *Diplazium esculantum, Docynia indica, Elaeagnus* sp, *Ficus* sp*, Houttuynia cordata,* Musa sp*, Phyllanthus emblica, Prunus persia, Pyrus communis, Solanum nigrum, Zizyphus mauritiana* and *Syzigium cumini* were consumed in the fresh form and commonly sold in the local markets to supplement income. Another report also from Arunachal Pradesh indicated 156 species of wild plant species traditionally used by tribal people for food purposes Reddy *et al*. (2007).

A total of 50 indigenous fruit species were documented by Saka *et al.* (2006) in Miombo, South Africa. Among those most promising fruit species were *Uapaca kirkiana, Parinari curatellifolia, Strychnos cocculoides* and *Sclerocarya birrea.* The fruits were either consumed fresh or processed as spices, soups, jam, juices, alcoholic beverages and yoghurt.

The tribal population have harvested the plentiful minor fruits grown in the wild both for domestic consumption and for monetary benefits through sales. The tribes of Aravali hills, Western Ghats tropical arid zones of India have wisely used the minor fruits for food and medicine. Consumption of wild fruits by *Palliyar* tribes of the Western Ghats of Tamil Nadu was documented by Arinathan and associates (2007). The survey indicated 171 edible plant foods of 67 plant families were consumed as food in different settlements of *Palliyars* in the south eastern slopes of Western Ghats, among which 68 comprised the fruits which were either utilized ripe or unripe forms. Ramachandran (2007) surveyed Anamalai hills of Western Ghats of Coimbatore district of Tamil Nadu to identify the edible plants utilized by tribal communities such as *Kadars, Pulaiyars, Malasars, Malaimalsars and Madhuvars*. The study revealed 74 edible plants among which 49 fruit/seed yielding trees were identified to be traditionally consumed to meet the dietary requirements. It was opined that many of these less familiar plants could be investigated to meet the food and nutrition security of the nations.

Kala (2007) revealed that 15 wild edible plants were popular for cultivation by people of Uttaranchal hills of Indian Himalayas. Arid fruits of *Myrica esculenta, Berberis campestris*, *Rubes ellipticus* and *Ficus auriculata* were the common priorities for cultivation. The former three fruits were reported to be consumed as seasonally.

Table 1. Minor fruits of India#

Sl.No.	Botanical name	Colloquial names
1	*Aegle marmelos Correa.*	Bael, *vilvam, bilpatre, bilva*
2	*Artocarpus heterophyllus*	Jack fruit, Halasu, Kanthal, Pal pazham
3	*Artocarpus hirsute*	*Kadu halasu, kathal, idichakka*
4	*Artocorpus lakoocha*	*Votehuli, barhar, llagusam,wotombe*
5	*Atalantia racemosa wight and Arn.*	*Kattu elumichai,*
6	*Atrocarpus heterophyllus* Lam.	*Pala, Halasu, panasa, kanthal*
7	*Averrhoea Bilimbi*	Bilimbi, *kamaleku*
8	*Averrhoea carambola*	Caramboa, kamrakh
9	*Baccaurea sapida*	Latka
10	*Bassia latifolia*	*Hippe, mahua, ippa, iluppai*
11	*Bridelia retusa* Spreng.	*Kadukaipalam*
12	*Buchnania lanzen*	*Charoli*
13	*Canthium parviflorum* Lam.	*Paryakarai/malakkarai*
14	*Capparis zeylanica* L.	*Kathalikai*
15	*Capsicum fruitescens* L	*Kanamillakukeerai*
16	*Carissa carandas* L.	*Kilakkay, karonda, , karamcha, kavale*
17	*Chomelia asiatica* O-kze	*Therani*
18	*Chrysophyllum cainto*	Star apple,
19	*Citrullus lanatus*	*Matiro*
20	*Citrus auruntium*	*Kanchi kai, santra,kithilai, kamala pandu*
21	*C. grandis*	*Sakkare kanchi,* pomelo
22	*C. jambheri*	*Dodle kai*
23	*C. limon*	*Gajanimbe, bijapura, bara nimbu*
24	*C. medica*	*Madala hannu*
25	*C. sinensis*	*Sweet orange, kittale, mosambi*

26	*Coccinia grandis* L. *Voigt*	*Kovai, tondekayi, kova kayi, donda kaya,*
27	*Commiphora caudate*	*Mangkiluvai*
28	*Commiphora pubscens*	*Kodikiluvai*
29	*Cordi oblique* Willd.	*Virusu*
30	*Cordi oblique* Willd.	*Kal virusu*
31	*Cordia gharaf*	*Goondi*
32	*Cucumis callosus*	*Kachri*
33	*Cucumis melo*	*Kachro,musk melon, kharmuj, karbooja,*
34	*Dillenia indica*	Elephant apple
35	*Diospyros foliolosa* Wall.	*Thumla*
36	*Diplocyclos palmatus* (L.) Jeffrey	*Aattupudal/malaipusanni*
37	*Elaeagnus conferta*	*Halige hannu*
38	*Elaeocarpus floribundus*	Jalpai
39	*Elaeocarpus tectorius* (Lour.) Poir.	*Kotla,*
40	*Emblica officinalis*	Aonla, amla, nelli, bettada nelli
41	*Ephedra foliate*	*Lana*
42	*Eribotrya japonica*	Loquat
43	*Erythroxylon monogynum* Roxb.	*Chemmana*
44	*Eugenia jambolana*	*Nerale*
45	*Eugenia jambos*	*Pannerale*
46	*Flacourtia Montana*	*Mullusampige hannu*
47	*Feronia limonia*	Wood apple
48	*Ficus carica*	Fig, mar, angoor,
49	*Ficus racemosa* L.	*Atthi*
50	*Ficus religiosa* L.	*Arasu*
51	*Flacourtia indica* (Burm. F.) Merr.	*Sampige hannu, Mullumayilai*
52	*Flueggea leucopyrus*	*Hoolihannu*
53	*Garcenia cambogia*	*Uppagi*
54	*G.indica*	*Bilimurugal, Amsol*
55	*G.morella*	*Arishina gurge*

56	*G.xanthochymus*	*Garcinia*
57	*Gardenia gummifera* L. f.	*Karadivetchi*
58	*Glycosmis maurtiana*	*Glycosmis*
59	*G. pentaphylla* (Retz.)	*Panam palam/chedi*
60	*Grewia hirsute* Vahl	*Chinnaachu*
61	*G. laevigata* Vahl	*Karuachu*
62	*G. tiliifolia* Vahl	*Valakkaimaram*
63	*G. villosa* Wild	*Vattachi*
64	*G. flavescens* Juss	*Odaachu*
65	*G. heterotricha* Mast.	*Periyaachu*
66	*G. tenax*	*Gangerun*
67	*Heracleum rigens* Wall.	*Kattu kottamalli*
68	*Lantana camara* L.	*Uni*
69	*Luffa acutangula* L.	*Kattu pirkku*
70	*Mangifera indica* L.	Wild *Mango, Maa*
71	*Miliusa eriocarpa*	*Nedunaarai*
72	*Mimusops elengi* L.	*Bakula, Mahilam*
73	*Momordica charantia*	*Kuruvithalai paakakai*
74	*M. concanensis* Nimmo ex Gibs	*Palupaakakai*
75	*Mukia maderaspatana* L.	*Musumusukkai*
77	*Murraya paniculata*	*Kattu kariveppilai*
78	*Osyris quadripartite*	*Sundaravalli*
79	*Passifiora edulis*	Passion fruit
80	*P. foetida*	*Poonakkali*
81	*Phyllanthus acidus*	Star aonla
82	*P. emblica* L.	*Nelli, Kattunelli*
83	*P. reticulatas* Poir.	*Poola*
84	*Physalis minima* L.	*Kutty thakkali*
85	*Polyalthia suberosa*	*Kodinaaval*
86	*Polyalthia cerasoides* (Roxb.) *Bedd.*	*Nedunarai*
87	*Psidium guajava* L.	*Kattukoyya*
88	*Rubus niveus* Thunb.	*Maekattu illanthai*

89	*Secamone emetic* (Retz.) R.	*Karuppattikodi*
90	*Solanum anguivi* Lam. var. *Multiflora*	*Kattuthudhuvalai*
91	*S. erianthum* D. Don	*Kattuchudai*
92	*S. melongena* L. var.	*Mullukathri, begun, baingan*
93	*S. nigrum* L	*Milaguthakkali*
94	*S. pubescens* Wild	*Kattusundai*
96	*S. torvum* Sw.	*Kattusundai, sondekai, sundakkai,*
97	*S. trilobatum* L.	*Thudhuvalai*
98	*Spondias pinnata*	*Indian hogplum* , Amrat
99	*Syzygium cumini* (L.) Skeels	*Naval,* jambu, jamun,
100	*S. samarangense*	Jumrool
101	*Terminalia belarica*	*Tarehannu*
102	*Tamarindas indica* L.	Tamarind, *Puli kai, hunase leaves, amli*
103	*Uvaria rufa Blume*	*Thevakodi*
104	*Ziziphus mauritiana* Lam.	Ber, *Periya ilanthai, bare*
105	*Z. numularia*	*Wild jujube*
106	*Z. oenoplia*	*Paragihannu*
107	*Z. oenoplia* (L.) Mill.	*Pulichi*
108	*Z. xylopyrus* (Retz.) *Wild.*	*Mullukottai*
109	*Annona cherimolia*	*Cherimoyar, hanuman phal,*
110	*Durio zilethinus*	*Durian*
111	*Schleichera trajunga*	*Kusum, sagadekendala*
112	*Vaccinium laschenaulti*	*Kuraunda, kila pazham, wakkai*

 # Source: Anonymous (1998), Arinathan , *et al*. (2007), Das (2009), Gopalan, *et al*., (1998), Ramachandran, V. S. (2007), Rao *et al*. (2011), and Rathore, M (2009).

Mishra and coworkers, (2007) revealed that *Capparis* species such as *C. decidua, C. cartilagenea, C. spinosa, C. cappris moonii, C. zeylanica, C. separia, C. grandis, C. heyneana* were used as vegetable and for preparation of pickle. It was indicated that the *Capparis* species seems to have tremendous scope to provide different therapeutic compounds as analgesic, anti-inflammatory and biochemicals to treat cardiac, renal, skin and central nervous system problems.

Murugn *et al*. (2008) explored Nubra, one of the valleys of *Ladakh* for traditional wild edible plants and identified 27 plants species of 18 families to be used in forward preparation. Several fruits such as *Bunium persicum* (Boiss) Fedtsh and *Carum cavi* (Linn.) were traditionally used in treatment of stomach disorders. Fruit Juice and squash of *Hippophaen rhamnoides* var. *turkestanica* Rousi were reported to be used as jam by people of *Ladakh* as multivitamin tonic.

Different minor fruit such as jackfruit (*Artocarpus heterophylus*), bael (*Aegle marmelos*), ber or Indian jujube (*Zyziphus mauritiana*), chalta or elephant apple (*Dillenia indica*), jamun (*Syzygium cumini*), fig (*Ficus carica*), jalpai (*Elaeocarpus floribundus*), loquat (*Eribotrya japonica*), karonda (*Carissa carandas*), star apple or caimito (*Chrysophyllum cainto*), star aonla (*Phyllanthus acidus*), amrat (*Spondias pinnata*), wood apple (*Feronia limonia*) and tamarind (*Tamarindus indica*) were reported to be commonly consumed and cultivated in Tripura by (Das and Prakash, 2009). The region was revealed to be one of the richest reservoirs of genetic variability and diversity of different minor fruits, which existed in plant types, morphological and physiological variations, resistance to disease and pests, adaptability and distribution. It was emphasized to exploit the potential usefulness of such valuable resources, in combating the challenges of food and nutritional security to the ever-increasing population.

Around 600 plant species in Indian forests were enumerated to have food value by Rathore (2009). It was indicated that about 20 per cent of the plants occurring in the forests were reported to have direct utility to mankind Arid zone vegetation comprising of *ker Capparis decidua, lasora (Cordia dichotoma),* ber *(Zizyphus mauritiana), bordi (Zizyphus nummularia), jal (Salvadora oleoides), hingota (Balanites aegyptiaca)* and *khejri (Prosopis cineraria)* played an important role in the nutrition of children in rural and urban areas alike and were relished. It was opined that most of the fruits despite recording good amounts of protein, energy, fiber, vitamin A and vitamin C were often under valued and underutilized might because exotic fruits have become more accessible. It was also indicated that most of these were not cultivated and there was scant and dispersed knowledge about such fruits. Production and consumption of such fruits could provide a dietary supplement as well as commercial exploitation opportunity.

Food uses of wild edible plants were also indicated in six tribal communities of Pathanamthitta of Kerala (Binu, 2010). The communities of *Malappandaram, Urali, Malaarayan, Ulladan, Malavedan* and *Malakurava* had the knowledge of wild edible plants in their surrounding forests. Unripe fruits were consumed fresh or cooked in the form of curries and other products.

Ballabh and associates (2011) reported that 31 plant species were used as wild edibles by the tribal communities of *Ladakh* region. Edible plants, such as *Berberis lyceum, Elaeagnus angustifolius, Ephedra gerardiana, Hippophae rhamnoides, Morus alba* and *Prunus armeniaca,* as bulbs, roots, leaves, leaf-stalks, fruits and seeds were used in different ways. *Mentha longifolia, Lactuca sativa, Elsholtzia densa, E.eriostachya* was consumed as chutneys which were used as flavouring food products after dehydrating. Thus the wild edible plants played an important role in daily life of tribal people.

2.2 Physico chemical characteristics of minor fruits

Physicochemical characteristics determine edibility and handling suitability for processing and value addition. Parameters such as size, shape, handling properties, storability, edible portion, chemical constituents and sensory quality influence the popularity of fruits for end use.

2.2.1 Physical characteristics of minor fruits

Variation in morphological characters such as colour, shape, texture, length, girth and weight was revealed among 34 different fruits of Western Ghats of Uttara Kannada district, under the four forest ranges (Anon, 1998). Morphological characteristics of underutilized domesticated citrus fruits of Western utilized domesticated citrus fruits of Western Ghats of Uttara Kannada; Karnataka was evaluated by Nalini *et al*. (2001). Considerable variation in morphological characteristics of *Citrus medica, C. jambheri, C. aurunthium, C. lemon, C.sinensis and C.grandis* fruits were revealed. *C.medica* recorded highest weight (1123 g) followed by C. grandis (1053 g). Edible portion was highest in *C. sinensis* followed by *C. jambheri*.

Bhardwaj and Yamdagni (2003) reported that ripe mulberry fruits *Morus nigra* were longer (5.35 cm) and heavier (2.66 g) than *Morus alba* (4.88 and 1.74 cm, respectively) fruits, however edible portion in both fruits was 100 per cent. Morphophysiological diversity in wild mango and garcenia fruits from different locations of Western Ghats of Uttara Kannada district, Karnataka was revealed by Nalini and Chimmad (2005 a and b). A wide variation was indicated among the fruits of *Garcinia indica* (*ote kai, murugala*, *amsol*), *G. cambogia* (*uppage*), *G morella* (a*rishina gurge*) and G. *xanthochymus*.

Morphological variations in thirty Indian elite genotypes of karonda (*Carissa carandas*) were indicated by Singh and co workers (2006). The study revealed that there was wide variation among the accessions. The fruits were oblong, broad-ovoid or round, fruit colour was purple and red-white; fruit weight ranged from 1.85 to 6.0 g ; fruit length from 0.90 to 2.40 cm; diameter from 0.32 to 2.15 cm; seed weight from 0.26 to 1.40 g and pulp content from 1.35 to 4.67 g.

Kalyoncu *et al*. (2009) measured physical parameters of sweet cherry (*Prunus avium* L.). It was reported that the fruit mass, length, width and thickness were 2.76 g, 17.68 mm, 15.60 mm and 14.89 mm, respectively. Reddy and Chikkasubbanna (2009) evaluated physical parameters of amla (*Emblica officinalis*). The fruit weighed 14.89, 2.86 cm in diameter and 2.21 cm height. Average weight of whole *singhara* (water chestnut *Trapa natans* L.) was indicated to be 22.56 g with edible portion of 53.41 per cent (Singh *et. al*., 2010).

The weight, length, width and volume of were 9.55 g, 3.88 cm, 2.98 cm and 7.60 ml in improved variety of jamun fruit (*Syzygium Cuminii* L*)* where as the local variety recorded 6.71 g, 2.73 cm, 2.10 cm, and 5.33 ml, respectively. The edible portion was 69.10 per cent in improved variety and in the local it was 39.19 per cent by Sheikh (2011). Thus the physical parameters varied among different minor fruits.

2.2.2 Chemical composition of minor fruits

Chemical constituents of fruits influence sensory quality, shelf life, utilization and value addition potentials. Information on chemical composition would not only help in reaping better benefits but also enable in application of sustainable preservation techniques. Many studies to explore the chemical composition of minor fruits are reported.

Haware and Rao (1979) indicated variations in moisture (87.50 to 90.00%), acidity (4.10 to 5.99%), TSS (3.00 to 4.00%), protein (0.74 to 2.20%), reducing sugar (0.93 to 2.25%), non-reducing sugar (0.60 to 1.20%), total sugars (1.65 to 3.45%), total minerals (0.80 to 1.13%), iron (3.33 to 4.95mg/100g), anthocyanin (0 to 0.30 O.D), total carotenoids (0.10 to 0.41 mg/100 g) and ascorbic acid(10.26 to 15.38 mg/100g) in three varieties of karonda.

Nutritive values of 40 edible wild fruits of Kathamandu valley of Nepal were determined by Bajracharya (1980). It was concluded that most of the wild fruits were comparable to cultivated fruits in nutritive value and were suggested for commercial cultivation.

Nutrient composition of African star apple (*Chrysophyllum albidum* G. or C. *Africanum, A. Decandolle*) was analysed by Nwadinigwe (1982), in Nigeria. Moisture, ash, crude fiber, oil, protein, starch, sugar and ascorbic acid contents were reported to be 72.34, 2.74, 14.89, 28.37, 11.62, 14.72, 19.19 and 9.64 g, respectively per 100 g fruit. The minerals such as calcium, iron, potassium, magnesium, phosphorous and zinc levels were indicated to be 26.9, 2.0, 0.2, 36.4, 44.6 and 3.4 mg per 100 g, respectively. The authors suggested it to be a cheap source of several important nutrients.

Ker fruits (*Capparis deciduas* Edgew) recorded 14.88 per cent protein, 7.43 per cent fat, 5.96 per cent ash, 12.32 per cent crude fibre and 59.41 per cent digestible carbohydrates (Chauhan *et. al*., 1986). Further β-carotene, ascorbic acid, Ca, P, Fe, Cu, Zn and Mn were recorded to be 5.40, 120.70, 90, 179, 3.5, 1.1, 1.6 and 1.9 mg/100 g, respectively. Albumin, globulin, prolamine and glutelin fractions formed 53, 16, 11 and 12per cent, respectively of total protein in the fruit. The fruit was revealed to be free from tannins, trypsin inhibitor and haemagglutinin activity but contained 304 mg/100 g of phytic acid.

Considerable variation in moisture, protein, fat, ash, carbohydrate and crude fiber content ranging from 84 to 89, 0.09 to 0.16, 0.06 to 1.0, 0.04 to 0.08, 10.54 to 14.48 per cent, respectively, among the different species underutilized domesticated citrus fruits of Western Ghats of Uttara Kannada, Karnataka was reported by Nalini *et al.* (2001). High ascorbic acid content was reported for *C. lemon* (58.51 mg/100 g). Iron and calcium contents were high in *C. aurunthium* and *C. lemon* (0.83 and 80.48 mg/100g, respectively). Total phenols ranged from 1.86 to 3.59 and tannin from 2.73 to 7.78 mg/100 g in the under exploited citrus fruits.

Variation in biochemical component of mulberry fruit species was reported by Bhardwaj and Yamdagni (2003). *Morus alba* recorded 23.90 per cent TSS, 0.98 per cent acidity as per cent citric acid, 14.90 mg/100g ascorbic acid, 22.62 per cent total sugars and 1.36 per cent pectin as calcium pectate. The fruit recorded 1.59 per cent crude fiber and 1.61 per cent protein on dry weight basis. *Mours nigra* exhibited 12.97 per cent TSS, 2.35 per cent acidity (as % citric acid, 15.80mg/100g ascorbic acid, 11.55 per cent total sugar, 8.39per cent reducing sugar and 1.28 per cent pectin as calcium pectate. Anthocyanin content was 18.90 mg/g in the fruit. Calcium and magnesium contents were 80 and 100mg in fruits of both the species of mulberry. Iron, Zinc and copper content were higher in *mours alba* (340, 59 and 12 ppm, respectively) than in *Mours nigra* (324, 49 and 11 ppm, respectively).

Black mulberry (*Morus nigra*) fruits grown in Canary Islands recorded a range of values for TSS (13.0 to 17.5 ºBrix), pH (3.1 to 3.36), titratable acidity (16.21 to 28.16 g/L citric acid), citric acid (20.0 to 34.0), lactic acid (0.17 to 0.26), anthocyanins (200 to 260 mg/100ml), the potassium (3075 to 4000ppm) as revealed by Darias *et al.* (2003).

Naik *et al*. (2003) reported that the edible portion in citrus fruits varied from 55 to 65 per cent whereas it was 97 to 100 per cent in bilimbi and carambola fruits. The fruits exhibited higher moisture content (98.50%) compared to citrus fruits (85.32%). Ascorbic acid content was high in citrus fruits (27.50%) compared to bilimbi and carambola fruits. Potassium content was 126.66, 108.33, 125.00 and 79.50 mg/a00g in bilimbi, carambola, jambheri and sheddock, respectively. Sodium content in citrus fruits was high (28.22 mg/a00g) compared to that of carambola and bilimbi fruits (17.50mg/100g). Calcium content varied between 26.66 to 28.88mg/100g in citrus fruits while it was 14.22 to 19.55 mg/100g in bilimbi and carambola fruits, respectively.

Gwerrero and associates (2004) analyzed 11 varieties of ber from southeast Spain for fatty acid and β-carotene contents and indicated that medium chain fatty acids were most abundant in all the samples. Carotene content was comparable with other fruits varying from 4.12 to 5.98mg/100g on dry weight basis; however on fresh weight basis the fruits recorded 38µg RE/100g.

Paul and Shaha (2004) determined nutrient composition of jambu (*Syzigium cumini*), wood apple (*Limonia acdissima*), star apple (*Eugenia javonica*), pomeloe (*Citrus maxima*) and indicated high fiber, protein, fat, riboflavin, calcium, phosphorus and iron contents (4.9, 6.9, 0.5 g/100 g , 0.15, 28.5, 98.9 and 0.6mg /100 g, respectively). Moisture and ascorbic acid contents were highest in star apple (90.4% and 45mg/100 g). Star apple and pomeloe recorded β carotene of 120mg/100 g.

Karonda recorded average moisture, total soluble solids, total sugars, titrable acidity content pH to be 72.36 per cent, 19º Brix, 10.22 per cent, 0.35 per cent and 2.72, respectively (Gaikwad and co workers 2005).

Nutritive value of wild edible fruits of Khasi tribes of Meghalaya, India was reported by Murugkar and Subbalahshmi (2005). It was revealed that *Solanum indicum* berries recorded high fiber (47.2%) and vitamin-C (826.4 mg/100 g). High values for zinc were recorded in *Vangeria spinosaa* fruit, where as *Prunus nepalensis* contained high amounts of β carotene 257.1µg per cent, besides vitamin- C (608.9mg %). It was concluded that wild edibles consumed by Khasi tribes were nutritious and suggested to be popularized for commercial exploitation owing to low cost.

Chemical diversity in wild mango fruits from different locations of Western Ghats of Uttara Kannada, Karnataka was revealed by Nalini and Chimmad (2005).

Sharma and associates (2006) recorded that sea buckthorn (*Hippophe rhamnoid* L.) exhibited 12 to 16 per cent TSS, 2.5 to 3.5 per cent acidity, 300 to 600 mg ascorbic acid and pH of 1.2 to 1.8. The juice yield of fruit was indicated to be 58 to 60 per cent. Thus variations in chemical composition of several minor fruits were indicated by investigators.

2.3 Storage quality of minor fruits

Good storage quality of fruits help in better consumption and utilization at house hold level. The fruits with poor shelf life need immediate attention for utilization either for consumption or for processing.

The post-harvest changes in two litchi (*Litchi chinensis* Sonn.) cultivars 'Hei Ye' and 'Chen Zi' were studied by Paull *et al*. (1987). Fruits were stored in a paper bags or a closed polyethylene bags at 22 or 2° C. In 'Hei Ye' pericarp browning was reduced by storage at 22° C in a closed polyethylene bag. Storage at 2° C delayed the onset of pericarp browning, but decay was a problem 20 days after harvest.

Different packaging strategies to prolong shelf life of minimally processed lampascioni (*Muscari comosum*) fruits were explored by Conte *et al.* (2008). The fruits were dipped in solutions containing 1.0 per cent citric acid and 8.0 per cent calcium chloride followed by coating with 5.0 per cent sodium alginate and packed in two types of polymeric films viz., polypropylene film and polyester-based biodegradable film. The treated fruits were stored at 5 ºC for 20 days. Results indicated that the alginate coated fruits packed in polyester-based biodegradable film film were best preserved over the entire storage period.

Post harvest quality of kiwi fruit (*Actinidia arguta*) packaged in low or high vent clamshell containers and stored under room (22 ± 1 ºC, 45% RH) or refrigerated (2 ºC, 88% RH) conditions was evaluated by Fisk *et al*. (2008). Low-vent packaging was reported to reduce weight loss and refrigerated storage delayed ripening and extended storage life of fruits to 7 to 10 weeks.

Influence of different packaging systems on quality loss of ready-to-use cherries was assessed by Conte *et al.* (2008). The fruits were packaged in oriented polypropylene-based bag and in a bio-based polymeric matrix under ordinary and modified atmosphere conditions. It was suggested that under ordinary atmosphere conditions, the oriented polypropylene-based bag showed best performance. Under modified atmosphere, both the films exerted similar effects on the portioned fruit.

Tembo *et al.* (2008) indicated that ber (*Zizyphus mauritiana* Lamk.) stored in low temperature (5ºC), lost 48 per cent of weight during 12 week storage duration while the fruits stored in the ambient (22 ºC) and intermediate temperatures (15ºC) lost 70 and 75 per cent of weight, respectively. The fruits stored at low temperature exhibited better fruit colour, weight and prolonged shelf life.

Shelf life of whole water chestnut at ambient, refrigerated, frozen and aqueous condition was investigated by Singh and co workers (2010). It was revealed that fruits stored at frozen condition exhibited better storage life in terms of weight loss. The fruits stored at ambient were reported to decrease significantly in first ten days of ambient storage. Thus the storage condition, packing and the treatments influenced the shelf life of minor fruits, certain methods suitable for shelf life extension were evolved during the process.

2.4 Potential minor fruits for value addition

Minor fruits are treasure houses of several health promoting substances besides possessing acceptable sensory profiles. Value addition to such fruits would not only promote economic status of people but also promote health and nutrition status of people consuming such fruits. Many experiments are conducted to explore value addition potentials of such fruits.

Six species of figs, namely *Ficus glomerata, F. hispida, F. auriculata, F.semicordata, F. subincisa* and *F. palmate* were considered as income-generating tree crops based on the fruit yield and economics of jelly and jam production from fruits in the Kumaon

Garhwal Hills of India (Dhyania and Khali 1993). Naik *et al*. (2003) opined that per capita availability of fruits might be increased by using under exploited, nutritious but neglected fruits that grow abundantly in nature. Thirteen different fruits were abundantly grown in forests of Western Ghats and very few were indicated to be processed. *Averrhoa bilimbi, A. carambola, C. Jambheri* and *C. grandis* (Sheddock) were indicated to be promising for value addition and commercial exploitation.

Dheeraj *et al.* (2008) reported that fruit concentrate, cordial, jam, ready-to serve fruit drinks, chutney, candy, pickle and squash were the main products from minor fruits of Rajasthan. *Tumba* a perennial, desert under-utilized bitter desert fruit claimed to exhibit medicinal properties was subjected to three different treatments of soaking in buttermilk, saline solution and deflourinated lime solution at various concentrations to reduce its bitterness by Bhansaly and Dunkwal (2010). The application of deflourinated lime solution reduced the bitterness significantly and the fruits were acceptable for consumption. The authors suggested exploitation of such fruits for value addition.

Clrici and Carvalho-Silva (2010) reported that eggfruit, blackberry, Brazilian guava, atemoya, bacuri, sweetstop, star fruit, feijoa, cactuspear, fruit of wolf, breadfruit, jaboticaba, jackfruit, rose apple, lychee, mangaba and marolo were though consumed by people of Brazil, were not industrially exploited and remained as main agricultural products. The fruits were although processed on small scale as jellies and sweets the need to initiate competitive agribusiness in the producing area to enhance local economics was stressed. Similarly, Ndabikunze *et al*. (2011) indicated that indigenous Tanzanian minor fruits such as smelly berry (*Vitex mombassae*), wild loquat (*Upaca kirkiana*) and marula plum *(Sclerocarya birrea)* exhibited potentials for value addition.

2.5 Value addition to minor fruits

Many types of value added products are being produced at both household and commercial levels with different popular fruits cultivated world over. Although some fruits such as kokum are explored for commercial processing, there are numerous minor fruits which need to be explored for value addition for commercial processing. Many investigators have suggested value addition strategies for several minor fruits.

2.5.1 Fruit beverages based on minor fruits

Many studies were conducted to investigate the potentials of development of fruit beverages based on minor fruits. Ready to serve beverages were developed with bilimbi and carambola by Banahatti *et al*. (2003), by using fruit juice, sugar and water in 4:2:8 ratio along with citric acid (0.5%). The product recorded 11.50, 13.80°Brix TSS and 1.20, 1.60 per cent titrable acidity in bilimbi and carambola fruits, respectively. The beverages were acceptable up to 5 months.

An investigation was undertaken to explore the feasibility of incorporation of karonda pulp as natural flavouring agent in ice-cream by Gaikwad and co workers (2005). Different types of ice creams with varying concentration of karonda pulp (w/w) were prepared using standard procedure. It was indicated that the ice-cream with 20 per cent pulp recorded overall acceptability of 7.51.

Utilization of karonda (*Carissa carandas L*.) juice in the manufacture of flavoured milk was explored by Hanwate and associates (2005). The flavoured milk containing 10.0 per cent karonda juice and 7.5 per cent sugar recorded highest acceptability with a score of 7.6 on nine point hedonic scale. On overall basis the flavoured milk containing 10 per cent karonda juice and 7.5 per cent sugar along with 0.5 per cent gelatin was most ideal.

Kumar *et al*. (2007) explored value addition potentials of ber by preparing RTS beverage from chemically preserved ber pulp. The protocol for preparation of pulp involved blanching the destoned fruit followed by homogenization to obtain pulp. The pulp was pasteurized and different preservatives such as sodium benzoate and sugar were added. Effect of storage on RTS beverage prepared using the stored pulp was studied. The study indicated reduction in ascorbic acid but increment in reducing sugars. RTS with KMS treated pulp exhibited better quality characteristics than the other sample.

Blended jamun- litchi nectar was developed by Chakraborty and Chaurasiya (2010), by blending the two juices in 130:70 ratio along with sugar (150 g), citric acid (2.5 g), sodium benzoate (15 mg) and water (800 ml). The product recorded a TSS of 16.2 per cent Brix and ascorbic acid content was 12 mg/ 100 g and titrable acidity was 0.3 per cent. Blend nectar was highly acceptable.

Chakraborty and Chaurasiya (2010) developed squash by blending 180 ml of passion fruit juice and 70 ml mango pulp along with other ingredients like sugar, citric acid, potassium meta bisulphite and water. The blend squash recorded 45.3 per cent Brix TSS, 1958.3 IU carotene, 3.9 per cent protein, 16.4 mg / 100 g ascorbic acid and 1.0 per cent titrable acidity. The product was reported to be well accepted in terms sensory parameters.

Thus studies indicated potentials of minor fruits for preparation of beverages.

2.5.2 Jams based on minor fruits

Processing of fruits for jam preparation is in vogue since hundreds of years. Newer varieties of food products are being processed with innovative ideas and new ingredients. Minor fruits are also being processed to develop acceptable jams with potential commercial values. Studies related with this aspect are discussed here under.

Sea buckthorn (*Hippophe rhamnoid* L.) a highly acidic fruit of Himalaya was blended with apple in varying ratios, among which the blend of 65:35 (apple: sea buckthorn) was reported to be highly acceptable with an overall acceptability score of 8.34 on a nine point scale (Sharma *et. al.,* 2006).

Smelly berry (*Vitex mombassae*), wild loquat (*Upaca kirkiana)* and marula plum *(Sclerocarya birrea)* jams were developed using baobab (*Adasonia dagatata*) seed powder and lemon extract as substitute for pectin by Ndabikunze *et al.* (2011). The fruits included Sensory quality in terms of colour, spreading on the bread, taste and overall acceptability on a seven point hedonic scale, revealed that marula plum jam with baobab powder or commercial pectin were superior in quality.

Vidya and Narain (2011) prepared wood apple (*Limonia acidissima*) jam which recorded good sensory quality in terms appearance, flavour, consistency, taste and overall acceptability.

Thus the available literature depicts the prospects of exploiting the minor for preparation of jams.

2.5.3 Pickling of minor fruits

Pickles are one of the favourite foods relished by people all over the world. Pickling industry is a enterprise in global context. The common cultivated fruits are industrially processed and earning huge revenues. Several minor fruits are also processed at home scale and there is a big scope for industrial exploitation of such fruits for commercial production of pickles. Studies are conducted to explore the potentials of minor fruits in commercial pickling process.

Shobha *et al.* (2004) developed two types of pickles from unripe ber using lemon juice or vinegar as acidifying agents and varied spice combination. It was indicated that pickle with the vinegar was better acceptable with crunchy texture, well balanced taste despite slight slimy mucilage it was acceptable. Thus authors concluded that value addition not only augments utilization but also provided variety and nutrition.

Value added pickle was developed with amla (*phyllanthus emblica*), ginger, green chillies and mango ginger by Reddy and Chikkasubbanna (2009). The fruit pieces were immersed in 10 per cent brine containing 2000ppm calcium chloride for four days. Spices and gingelly oil were other ingredients used in preparation of pickle. It was reported that organoleptic quality parameters in terms of appearance, aroma, flavour, taste and overall acceptability of pickle was highly appreciated.

Passion rind pickle was developed by Chakraborty and Chaurasiya (2010). The pickling process involved curing the rind of passion fruit in salt (20%) for 6 days. The rind pieces were mixed with passion fruit juice filled in sterilized jars and stored at ambient temperature (25-37 ºC). The pickle was appreciated by the panel. Thus the studies indicated good acceptability of pickles of different minor fruits.

2.5.4 Candies based on minor fruits

Fruit candies are good replacement for sugar candies for they provide substantial amounts of micronutrients and photochemical, candies of minor fruits like amla have become important adjuncts in the diet of people recently. Studies are conducted to explain the potentials of minor fruits in preparation of candies.

Osmotic dehydration was accomplished in the fruits with simultaneous increment of sugar strength from 30 to 70 º Brix. The osmotically dried fruits were subjected to convection drying at 60º for 48 h. The sensory evaluation of the product rated the product astringent to less astringent. The product colour changed from dark red to light yellow.

Acceptable fruit candies were developed by Banahatti *et al*. (2003) by boiling preserves in syrup to 70°Brix followed by dehydrating in a hot air oven (65°C) for 48 h. Product recorded titrable acidity of bilimbi and carambola fruit candies were 2.10 and 3.00 per cent, respectively, carambola candies were highly acceptable for three months. Dehydration by smoking of deseeded *Garcenia gummigatta* fruits to obtain the dried rind was indicated to be one of the ways of traditional value addition methods.

2.5.5 Other value added products

Rodrigues *et. al*. (1964) reported that canning of water chestnut in 0.1 per cent citric acid (pH 4.2) followed by sterilization for 15 minutes was reported to be a suitable processing technique. It was reported that treatment with citric acid (0.1M) markedly extended the shelf life of water chestnut, besides inhibiting surface coloration and loss in eating quality (Peng *et al.,* 2004). Cordenunsi and co workers (2003) opined that cold storage was an efficient way preserving strawberries in terms of sensory and nutritional qualities.

Shobha and co workers (2004) standardized protocol for value addition to unripe ber (*Zizyphus mauritiana* Lamk), ber chips, rings, osmotic exudates as RTS beverage and burfee were highly acceptable.

Chhetri and Gauchan (2007) reported that lapsi (*Choerospondias axillaries*) was traditionally exploited for preparation of *titaura* in Nepal. The fruits were also consumed fresh, pickled or processed in to a verity of appealing products.

Reena *et al*. (2007) developed blended guava-bael cheese and toffee with sugar, butter, glucose and the fruit pulp. The blended of guava and bael in the ratio of 1:1 was highly acceptable.

Bael (*Aegle marmelos* Correa.) slab and toffees were standardized by Sheoran *et al*. (2007), using different proportions of sugar, glucose along with butter and skim milk. Slab prepared with 35 per cent TSS, 0.50 per cent acidity, 0.07 per cent KMS and toffee prepared from 1kg pulp, 500g sugar, 100g commercial glucose, 100g skim milk powder and 100g butter were found most acceptable. A similar toffee was prepared using bael pulp, sugar, glucose, skimmed milk and other butter by Singh *et al*. (2007).

Chakraborty and Chaurasiya (2010) explored the feasibility for development of value added diversified foods from minor fruits like palmyra palm (*Borassus flabellifer* L), passion fruit *(Passiflora edulis),* jamun (*Syzgium cumini)* and jack fruit *(Artocarpus heterophyllus* L). Acceptable value added foods such as palm spread, palm toffee, palm burfee and jack-passion spreads were developed. Palm spread was prepared by cooking palm pulp and sugar (1:1) along with citric acid and skim milk powder at low flame to attain a final TSS of 65 to 68º Brix. In palm toffee preparation glucose, wheat flour and starch were additional ingredients, in palm burfee preparation khoa, butter and lime water were used along with fruit pulp and sugar. The preparation of jack-passion spread involved the mixing of pulps of jack fruit and passion fruit in 8:2 proportions with equivalent sugar. The mixture was cooked as low flame to 65 to 68 º Brix TSS.

Vidhya and Narain (2011) formulated fruit bar based on wood apple (*Limonia acidissima*). Sugar, milk powder, hydrogenated fat, citric acid were other ingredients used. The organoleptic quality measured on a 5 point scale revealed score of 4.8 each for appearance, flavour, consistency, taste and over all acceptability. It was reported that the product was acceptable without any significant changes in sensory and chemical characteristics during three months of ambient storage.

Quamachil (*pithecellobium dulce* L.) aril powder was prepared by Rao *et al.* (2011), by dehydrating the manually separated aril pieces at 45 to 50 °C for 6 to 7 h. The aril powder was suggested to be included in to ice creams, RTS, beverages, squashes, candies, mixed fruit jams, custards and bakery foods, owing to the characteristics flavour and taste.

Banahatti *et al*. (2003) developed preserves by osmotic dehydration. Acceptable product was obtained by pricking and boiling in 70°Brix syrup containing citric acid (2%). The products recorded 70.50, 70.50°Brix total solids and 2.40, 2.60 titrable acidity, respectively, for bilimbi and carambola.

Thus various value added products based on minor fruits were developed by several investigations. Many products were highly appealing and acceptable. Value added foods enhance diet quality in terms of acceptability and nutritional contribution, besides adding variety to the diet. Good shelf life of the value added products and aids increased utilization and market potentials. Many studies are conducted to evaluate the shelf life of value added products based on minor fruits. Studies related pickles and jams are detailed in the following paragraph.

2.6 Storage quality of value added products

Haware and Rao (1979) revealed that pickles of two varieties of karonda (*Carissa carandas*) bottled and packed in polythene bags and stored at room temperature (25 to 35 ºC) could be stored for eight months. Similar reports in ber pickle were indicated by Shobha *et al.* (2004). It was reported that the vinegar pickle exhibited a storage life of 6 months were as the ber pickle with lime juice could be stored up to 4 months.

Storage qualities of pickles developed with green and pink karonda with and without seed were carried out by Manivasagan *et al.* (2007). During 120 days of storage, a decrease in pH, acidity ratio, ascorbic acid, sensory quality was recorded but the TSS and browning increased. Pickle of pink karonda was rated better than that of green type. It was indicated that pH, TSS/acid ratio, ascorbic acid, non reducing sugars, organoleptic values decreased, while acidity, reducing sugar and browning increased during storage.

Mixed pickle of amla, ginger, mango ginger green chillies, spices and gingelly oil was reported to exhibit good storage life and was acceptable even after three months of storage Reddy and Chikkasubbanna (2009).

Passion fruit rind was processed in to pickles by Chakraborty and Chaurasiya (2010). The pickles exhibited high over acceptability score of 4.3 on 5 point scale even after a storage life of 12 months at ambient conditions of 25-37ºC, with microbial load within limits. It was reported that passion rind pickle recorded significantly low ascorbic acid content of 4.1 mg/100 g after storage at ambient for 12 months from an initial of 12.3 mg /100 g. However, Titrable acidity increased from 3.4 to 4.7 per cent.

2.6.1 Storage quality of jams of minor fruits

Ndabikunze *et al.* (2011) evaluated storage quality of jams from three indigenous fruits of Tanzania. The jam of smelly berry (*Vitex mombassae*), wild loquat (*Upaca kirkiana)* and marula plum *(Sclerocarya birrea)* prepared with pectin substitutes such as baobab powder and lemon extract were acceptable up to six months of storage at ambient. The pH, TSS and moisture content of the jams was not affected by storage, sensory quality in terms of colour, spreading on the bread, taste and overall acceptability was not adversely influenced by storage.

Wood apple (*Limonia acidissima*) jam was developed by Vidya and Narain (2011) recorded good storage life of 90 days at ambient without any significant changes in sensory quality parameters such as appearance, flavour, consistency, taste and overall acceptability. The total soluble solids, pH, pectin and ash values did not change significantly during storage.

Thus different studies conducted by various researchers revealed that numerous minor fruits exhibit great potential for value addition besides contributing to human diet and thereby nutrition.

3. MATERIAL AND METHODS

Many plant species including karonda thrive well in dry arid condition under subsistent soil condition with plentiful foliage that contribute advantageously to soil quality. Such plants play important role in greening the environment. The karonda species is special in this category because the plant bears abundant fruits with promising nutritive value and eating quality, besides value addition.

An investigation on the development of value added products and their storage studies from karonda fruits (both ripe and unripe) were carried out in the department of Food Science and Nutrition University of Agriculture Sciences.

3.1 Procurement of karonda

Karonda fruits and other raw materials required during the investigation were procured from local market in sufficient quantities in one lot. Physiologically mature but unripe karonda were procured during the maximum fruiting season, in the month of April 2011 and ripe fruits in the month of June 2011. Samples of the improved selection of karonda fruits were procured from orchards of K H Patil, Krishi Vigyan Kendra Hulkoti, Gadag district. The fruits were sorted manually to remove lighter foreign matter, immature, bruised and decayed fruits. Sorted fruits were washed in running water, pat dried lightly to remove surface moisture and subjected to experimentations. The methods employed in the experiments on unripe and ripe fruits are indicated under following paragraphs.

3.2 Morphological and Physical characteristics

Physical characteristics of fruits play an important role in determining acceptability of any commodity. Fruit morphology and physical characteristics were evaluated employing standard procedures.

3.2.1 Fruit morphology

Karonda fruits were subjectively evaluated for color, shape and appearance. The karonda fruits were dissected and seed and pulp were separated manually to record pulp and seed weight. Edible portion was calculated.

3.2.2 Weight (g)

Average fruit weight was determined by weighing the randomly selected ten fruits in an electronic balance and the average was calculated.

3.2.3 Breadth (cm)

Average fruit breadth was measured randomly selected ten fruits along horizontal axis touching each other on a graph sheet and the breadth was measured and average calculated.

3.2.4 Length (cm)

Average fruit length was assessed by placing ten randomly selected fruits along vertical axis touching each other on a graph sheet and the length was measured and average calculated.

3.2.5 Volume (ml)

Fruit volume was determined by measuring randomly selected ten fruits by amaranth seed displacement method (Anon., 1983). Ten fruits were used for displacement and the mean was calculated.

3.2.6 Density (g/cm^3)

Fruit density was calculated from weight and volume of karonda fruits (Anon., 1983) by using the formula

$$\text{Density} = \frac{\text{Fruit weight (g)}}{\text{Fruit volume (ml)}}$$

3.2.7 Test for pectin

Pectin strength of the fruit was assessed by adding methylated spirit to an aliquote of fruit extract, following the procedures described by Anonymous (1981).

3.3 Chemical characteristics

Chemical composition influences sensory properties, shelf life and value addition potentials. The chemical characteristics of the fruits were determined by standard procedures as indicated in the following paragraph.

3.3.1 Moisture (%)

Moisture content of fruits was determined by standard procedure of AOAC (Anon., 1990). Difference in the weight of the samples before and after drying was considered as moisture content and was calculated by the following formula

$$\text{Moisture (\%)} = \frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Sample weight}} \times 100$$

3.3.2 Total minerals (%)

Total mineral content of fruit was analyzed by igniting known weight of sample in a muffle furnace for four hours at 600℃ and weighed (Anon., 1990). The difference in weight was taken as to the minerals weight of ash. Total minerals calculated by the formula

$$\text{Total minerals (\%)} = \frac{\text{Weight of the crucible after igniting (g)} - \text{weight of crucible (g)}}{\text{Weight of sample (g)}} \times 100$$

3.3.3 Ascorbic acid (mg/100g)

Ascorbic acid content was estimated titrimetrically using 2, 6 –diclorophenol indophenol dye as per the modified procedure of AOAC (Anon., 1990).

$$\text{Ascorbic acid (mg)} = \frac{0.5\text{ mg}}{\text{Aliquot ml}} \times \frac{\text{Total volume(ml)}}{5\text{ ml}} \times \frac{100\text{ ml}}{\text{Weight of the sample}} \times 100$$

3.3.4 Total phenols (mg/100g)

Total phenolic content of karonda was estimated by the methods described by Bray and Thorpe (1954) using Folin Ciocalteau Reagent.

3.3.5 Phytic acid (mg/100g)

The phytic acid content of karonda was determined following the method by Wheeler and Ferrel (1971).

3.4 Storage quality evaluation

Storage quality of karonda fruits packed in either ventilated or non ventilated paper or polythene pouches (150 µ gage) was evaluated at ambient and refrigerated storage condition. Similar experimentation was conducted on fruits blanched for two min in water (98 ºC). Trials were also conducted to evaluate the storage quality by curing fruits by adding salt at 15 and 20 per cent at room temperature.

3.5 Value addition to karonda

Value addition helps in exploitation of fruits for better utilization and acceptance besides enhancing nutritional contribution. Value addition experiments were conducted to explore product development potentials in unripe and ripe karonda, employing popular traditional and unconventional methods.

3.5.1 Value addition to unripe karonda

Physicochemical characteristics of fruits vary depending on physiological maturity. Mature unripe green karonda were explored for preparation of chutney, powder, fruit candy and pickles by employing common popular processing technologies.

3.5.1.1 Karonda chutney

Traditional local method was employed for preparation of chutney. Details of the procedure and ingredients used are indicated in (Appendix I).

3.5.1.2 Karonda powder

Prepared fruit was ground coarsely and dehydrated in cabinet drier at 60 ± 1 º C by employing the procedures of Srivatsava and sanjeevkumar (2006).

3.5.1.3 Glazed green karonda

Trials for preparation of glazed green karonda with unripe fruits was carried out by following procedure described by Srivatsava and sanjeevkumar (2006) the prepared fruits were cured in sugar for 15 days with intermittent shaking and simultaneously increasing the syrup strength.

3.5.1.4 Karonda novel pickle and novel pickle with cured fruits

Unripe but physiologically mature karonda was used in the preparation of pickles. Both wild and improved selections of karonda were pickled by traditional method followed by local population (Appendix II) and using new ingredients such as *kalounji* seeds (*Nigella sativa* seeds). Fresh and cured karonda were pickled and the detailed procedure is indicated in Appendix III (http://4.bp.blogspot.com).

3.5.2. Value addition to ripe karonda

Ripe karonda is a detailed fruit with pleasant aroma and sourish sweet taste. Attempts were made to explore the potentials of ripe karonda by preparing beverages, candies and jam.

3.5.2.1 Karonda beverages

Standardization trials were conducted to assess the suitability of ripe karonda for preparation of beverages using the methods of Srivatsava and sanjeevkumar (2006).

3.5.2.2 Karonda candy

Ripe fruits were explored for preparation of fruit candy employing the methods of (Srivatsava and sanjeevkumar 2006). Ripe fruits were cured for 15 days in sugar with gradual increment in syrup strength. Cured fruits were dried in cabinate drier at 60ºC for two days.

3.5.2.3 Karonda fruit jam

Standardization trials for preparation of jam were conducted with wild and improved selection of karonda fruits, using the standard methods (Anon., 1981).

3.6 Storage quality of value added products

Effect of storage on quality of selected value added products was evaluated at ambient temperature, in terms of visual observation and sensory quality.

3.7 Sensory quality evaluation

The products were evaluated for sensory quality by a semi trained panel of 8 to 10 judges from the Department of Food Science and Nutrition of College of Rural Home Science, Dharwad using a nine point hedonic scale (Appendix IV).

3.8 Consumer acceptability of value added karonda pickle

Consumer acceptability of selected product was carried out among the students, house wives/women and staff of University of Agricultural Sciences Dharwad campus using FACT scale (Pardello and Schutz 2006) (Appendix V).

3.9 Statistical analysis

Suitable statistical tools were used for analysing and interpretation of the data. Analysis of variance was carried out to know the effect of storage, on fruit quality and acceptability of value added products.

4. EXPERIMENTAL RESULTS

Karonda is one of the hundreds of minor fruits which can thrive on substandard soils, under biotic and abiotic stress conditions. The plant prevents soil erosion and the abundant foliage helps in improving the salt quality. Acidic unripe firm fruits and the delicate aromatic globose fruits are relished by local population at household level. Results of the experiments conducted to explore the pysico chemical properties, storage quality and value addition potential are detailed in this chapter under respective sub titles.

4.1 Physico chemical characteristics of karonda

Utilization of fruits either for consumption or processing is influenced by physico-chemical properties. Characterization of karonda fruits would help in better utilization and application of value addition techniques. Results of the studies conducted on evaluation of physic chemical characteristics of both ripe and unripe karonda fruits is presented in the following paragraphs.

4.1.1 Morphology of karonda fruit

Fruit morphology determines the handling properties and shelf life. The morphological characteristics of unripe and ripe karonda fruit is presented in Table 2. Karonda being a drupe was found to be firm with green shining smooth skin when unripe (Plate1). The ripe fruits were dark purple almost black in colour were very delicate and the thin skin easily rupturable. The mean fruit weight was 1.82 g/fruit when unripe but ripe fruit weighed 2.10 g/fruit. The pulp weight was 1.62 g and 1.68 g/fruit in unripe and ripe fruits, respectively. The unripe fruit exhibited pale green pulp, while the ripe fruit pulp was dark pinkish purple with 3 to 4 seeds in each fruit. The mean volume of unripe fruit was 3 ml/fruit as against 2.90 ml/fruit in ripe fruits. The mean length and width of unripe and ripe karonda were 1.50, 1.31 and 1.30 and 1.17 cm, respectively. The density of unripe fruits was 0.66 (g/ml) and in ripe fruits it was 0.72 (g/ml). Thus the variation in morphological characteristics was evident.

4.1.2 Chemical components of karonda

Chemical components influence the sensory quality, shelf life and value addition preparation. Results of the analysis of chemical composition of unripe and ripe wild karonda fruits is presented in Table 3 on fresh weight basis. It was observed that unripe fruits recorded higher moisture content (81.83%) than the ripe fruits (80.66%). Total mineral content was 10.90 and 9.59 per cent in unripe and ripe fruits, respectively. Ascorbic acid content of unripe fruits was 17.00 mg/100 g and in ripe fruits it was 48.00 mg/100 g. The unripe and ripe karonda fruits recorded substantial levels of potassium (31.25 and 84.20 mg/100 g), zinc (1.44 and 5.83 mg /100 g), copper (1.09 and 2.05 mg/100 g), iron (0.83 and 13.90 mg/100 g) and manganese (1.15 and 0.93 mg/100 g), respectively. With regard to nutraceutical components the unripe and ripe fruits recorded 1.87 and 1.60 per cent dietary fiber with 0.43 and 0.40 per cent soluble and 1.44 and 1.20 per cent insoluble fractions, respectively. The fruits also recorded 4.27 and 2.5 mg phytic acid and 3.27 and 2.27 mg total phenols in unripe and ripe fruits, respectively.

It was observed that in improved karonda selection, unripe fruits recorded higher moisture content (80.73%) than the ripe fruits (80.17%). Total mineral content was 9.67 and 5.75 per cent in unripe and ripe fruits, respectively. Ascorbic acid content of unripe fruits was 18.02 mg/100 g and in ripe fruits it was 51.00 mg/100 g. The fruits recorded substantial levels of potassium (26.07 and 81.26 mg/100 g), zinc (1.50 and 3.26 mg /100 g), copper (1.12 and 1.92 mg/100 g), iron (0.1 and 10.33 mg/100 g) and manganese (1.21 and 0.20 mg/100 g), respectively in unripe and ripe fruits. With regard to nutraceutical components the unripe and ripe fruits recorded 2.07 and 1.95 per cent dietary fiber with 1.20 and 0.88 per cent soluble and 1.83 and 2.15 per cent in soluble fractions, respectively. The fruits also recorded 2.29 and 1.99 mg phytic acid and 4.27 and 2.50 mg total phenols in unripe and ripe fruits, respectively. Thus genotypic variation in the two fruits at two different stages was observed.

Table 2. Morphological characteristics of karonda fruits

Characteristics	Unripe	Ripe
Fruit	Drupe, globose, firm berry with thin smooth skin.	Drupe, globose, small, easily rupturable, thin smooth skin.
Colour	Light green	Lustrous, dark purple almost black and attractive.
Weight (g/fruit)	1.82	2.10
Pulp weight (g/ fruit)	1.62	1.68
Pulp colour	Pale green	Dark pinkish purple
Seed weight (g/fruit)	0.20	0.42
Pulp: seed ratio	8:10	4:00
Number of seeds/ fruit	3 to 4	3 to 4
Volume (ml/fruit)	3.00	2.90
Density (g/ml)	0.66	0.72
Length (cm/fruit)	1.50	1.30
Width (cm/fruit)	1.31	1.17

Table 3. Chemical components in karonda fruits per 100g

Nutrients	Unripe		Ripe	
	Wild	Cultivated	Wild	Cultivated
Moisture (g)	81.83	80.73	80.66	80.17
Total minerals (g)	10.90	9.67	9.59	5.75
Ascorbic acid (mg)	17.00	18.02	48.00	51.27
Potassium (mg)	31.25	26.07	84.20	81.26
Zinc (mg)	1.44	1.50	5.83	3.26
Copper (mg)	1.09	1.12	2.05	1.92
Iron (mg)	0.83	0.1	13.90	10.33
Manganese (mg)	1.15	1.21	0.93	0.20
Total dietary fiber (g)	2.07	1.87	1.95	1.60
Soluble dietary fiber (g)	1.20	0.43	0.88	0.40
Insoluble dietary fiber (g)	1.83	1.44	2.15	1.20
Phytic acid (mg)	2.29	1.23	1.99	1.84
Total phenols (mg)	4.27	3.27	2.50	2.27

4.1.3 Sensory attributes and utilization of karonda

Utilization of karonda is specific to its stage of maturity. The unripe fruits being sour with slight astringent taste were not consumable as table fruits, although traditionally savored by children in small quantities. Sensory attributes and utilization of karonda is presented in Table 4. The unripe fruits were firm with chewable soft seeds and edible portion was 89.00 per cent, excluding the seeds. Handling unripe fruits was found to be easy and could be stored for 3 to 4 days without any significant changes in quality characteristics. The ripe fruits were very delicate to handle but exhibited highly acceptable organoleptic characteristics. The fruits were sweet and sourish and consumable by all the age groups as such with edible portion of 80 per cent.

4.2 Storage quality of karonda

Weight of edible fruits of unripe karonda as influenced by package and packaging conditions at ambient temperature is presented in Table 5. The edible fruit weight was significantly influenced by storage treatments, packaging conditions during storage. On over all bases storage of fresh unblanched fruits yielded more edible fruits with lowered losses (Fig.1) at ambient storage. Paper bags were found to be better compared to polythene pouches irrespective of ventilation, the fruits stored in polythene pouches exhibited poor shelf life and resulted in maximum spoilage after four days of storage. Similar trend of poor shelf life of two to four days observed with blanched fruits stored in polythene bags at ambient. It was observed that 70 per cent edible fruit weight was retained in paper bags up to 12 days of storage, irrespective of ventilation thus at ambient condition paper bags without vent was found to be better. The blanching treatment did not extend the shelf life of fruits at ambient for the fruits stored in polythene packages. In general polythene bags were found to be unsuitable for storage of karonda at ambient condition.

Effect of refrigeration on storage of unripe karonda as influenced by ventilation and blanching treatment is indicated in Table 6. It was observed that fresh unblanched fruits could be stored effectively in refrigerator up to 18 days of storage and maximum edible fruit weight was recorded in those packed in ventilated polythene bags (77.09%), both ventilated paper bags and non ventilated polythene bags (68.41%) and lowest was recorded in non ventilated paper bags on 18^{th} day of storage (66.58%). However the blanched fruits were well preserved up to 18^{th} day of storage with highest edible fruit weight of around 66 per cent, up to 10 days of storage about 90 per cent of the fruits could be retain by blanching in polythene packages and in ventilated paper bags maximum loss (Fig. 2) of edible fruit was observed in those blanched fruits which were packed in non ventilated paper bags and stored in refrigerated conditions retaining edible portion to an extent of above 50 per cent.

Steeping fruits in brine is a common practice, followed at industrial and household levels prior to pickling. Results of the experiments conducted to extend the shelf life of unripe karonda fruits in brine, are depicted in Table 7. Initially fruits were dark green in colour and firm in texture with natural sour taste and flavor. The curing of fruits in salt resulted in gradual paleness in fruit colour in both the treatments. The fruits were firm and did not exhibit shriveling and wrinkling of the skin. However initiation of fermentation was observed in the first week of curing and the product exhibited fermented changes in both the treatments. But thereafter, release of gases and putrefactive fermentative changes were observed in the fruits steeped in 15 per cent brine. However the fruits steeped in 20 per cent brine maintained good quality and was a potential method for extending the shelf life unripe karonda.

Weight of the edible fruits of ripe karonda as influenced by package and storage condition stored at ambient temperature is presented in Table 8. The edible fruit weight was significantly influenced by treatments and storage conditions in paper bags. On over all base storage of fresh unblanched fruits yielded more edible fruits with lowered losses (Fig. 3) at ambient storage. The blanched fruit stored in ventilated paper bags exhibited better shelf life than the unblanched fruits and resulted in maximum spoilage after Four days of storage in case of unblanched fruits stored in ventilated paper bags at ambient condition. Thus at ambient condition paper with and without vent was found to be better with blanched fruits. In general paper bags were found to be suitable for storage of ripe karonda at ambient temperature.

Table 4. Characterization of karonda for sensory attributes and utilization

Characteristics	Unripe	Ripe
Taste and flavor	Sour, slight astringent	Sweet with slight sour taste. Highly acceptable fruity flavour.
Texture	Firm, seeds soft and chewy	Delicate
Edibility	Fruit usually not consumed as such but whole fruit is used for processing	Consumed fresh, traditionally not processed
Edible portion (%)	89.00	80.00
Handling properties at ambient	Easy, no special care needed storable for 3 to 4 days	Delicate to handle, spoil in 1or 2 days
Traditional uses	Processed in to chutney and pickle	Table purpose
Acceptability	Savored by children in small quantities	Acceptable to all age groups

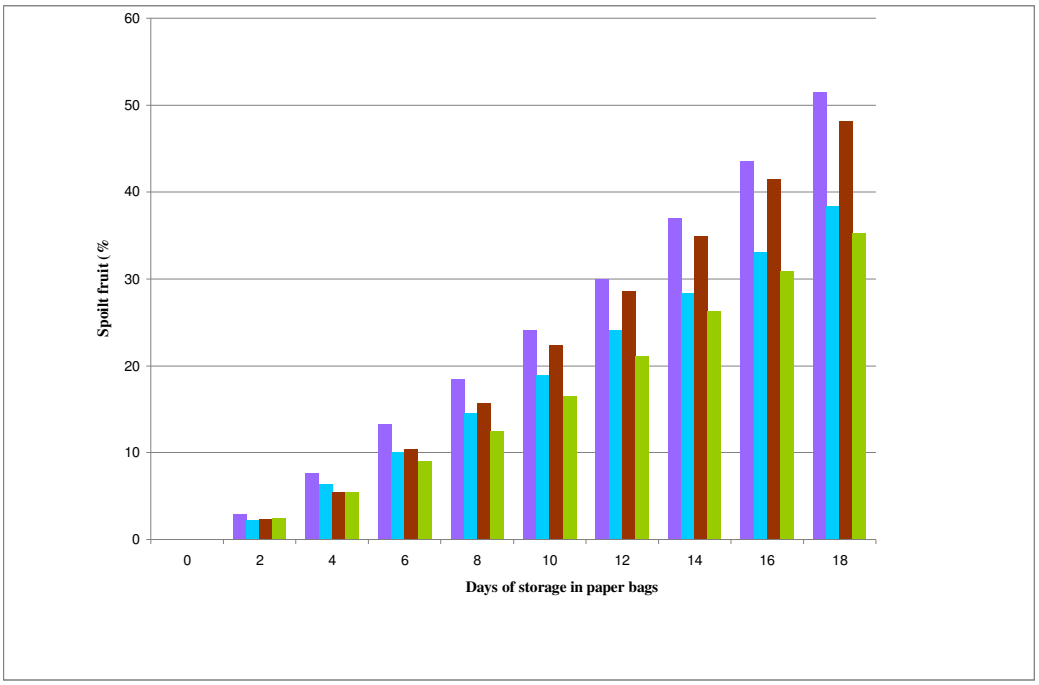
Table 5. Weight of edible unripe karonda fruits (%) as influenced by package and storage treatments at ambient

Days of Storage	Unblanched fruits				Mean	Blanched fruits				Mean
	Paper bags		Polythene pouches			Paper bags		Polythene pouches		
	Ventilated	Non ventilated	Ventilated	Non ventilated		Ventilated	Non ventilated	Ventilated	Non ventilated	
0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2	96.95	97.38	97.60	96.84	97.19*	97.33	96.86	96.21	98.21^{NS}	97.17*
4	92.05	92.48	93.41	93.21	92.79*	94.59	93.16	0.00	93.70	81.57*
6	86.24	88.28	0.00	88.94	65.87*	90.28	87.62	0.00	0.00	55.17*
8	80.81	82.89	0.00	83.90	61.90*	86.95	82.95	0.00	0.00	52.19*
10	75.00	77.85	0.00	78.27	57.78*	83.81	78.27	0.00	0.00	49.15*
12	68.86	71.82	0.00	73.20	53.47*	75.87	73.65	0.00	0.00	45.43*
14	61.53	66.80	0.00	66.96	48.82 *	69.39	67.17	0.00	0.00	41.48*
16	54.81	61.21	0.00	60.94	44.24*	60.62	60.96	0.00	0.00	37.32*
18	46.59	55.08	0.00	54.75	39.11*	50.93	55.66	0.00	0.00	32.88*
Mean	76.29*	79.38*	29.10*	79.70*	66.11*	80.98*	79.63*	19.62*	29.19*	59.24*

	Sem	CD
Treatment	0.22	0.63*
Storage days X Treat	0.64	1.79*

*=Significant at P≤ 0.05

NS=Non Significant



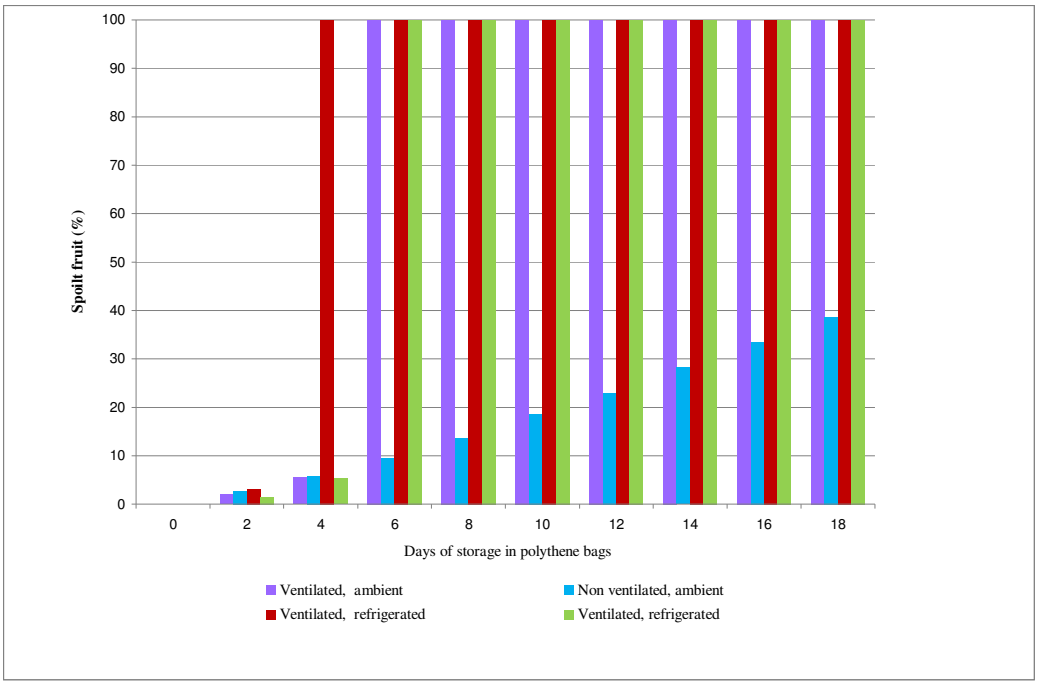


Fig 1b. Influence of ventilation and storage conditions on spoilage of unblanched unripe fruits

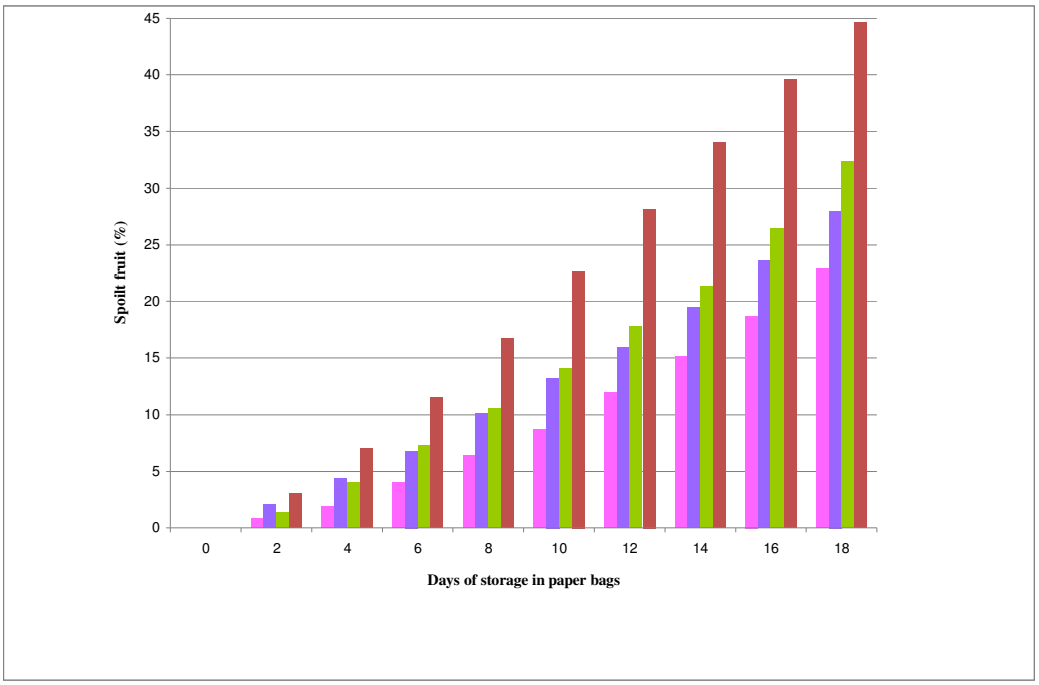
Table 6. Weight of edible unripe karonda fruits (%) as influenced by package and storage treatments at refrigerated temperatures

Days of Storage	Unblanched fruits				Mean	Blanched fruits				Mean
	Paper bags		Polythene pouches			Paper bags		Polythene pouches		
	Ventilated	Non ventilated	Ventilated	Non ventilated		Ventilated	Non ventilated	Ventilated	Non ventilated	
0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
2	99.06	97.50	98.36	98.34	98.32*	98.48	96.52	98.62	98.33	97.01*
4	97.87	94.79	96.70	96.04	96.35*	95.45	92.04	95.45	96.03	95.55*
6	95.51	91.89	95.40	93.29	94.02*	91.66	87.00	91.94	93.14	92.47*
8	92.81	87.93	93.91	89.30	90.99*	88.03	81.12	88.25	89.12	88.81*
10	90.22	84.19	91.97	85.73	88.03*	83.98	74.37	83.46	85.46	84.92*
12	86.57	80.97	90.04	81.92	84.88*	79.74	68.18	78.62	81.52	80.94*
14	82.96	76.74	87.18	77.69	81.14*	75.72	61.55	73.13	76.86	76.47*
16	78.96	71.80	82.55	73.40	76.68*	69.88	55.25	67.26	71.60	71.33*
18	74.26	66.58	77.09	68.41	71.59*	63.19	49.58	60.02	66.69	65.72*
Mean	88.80	85.24*	90.54^{NS}	85.09*	88.20*	83.07*	76.56*	82.02*	84.49*	85.32*

	Sem	CD
Storage days	0.19	0.53
Treatment	0.21	0.60
Storage days× Treatment	0.60	1.68

*=Significant at P≤ 0.05

NS=Non Significant



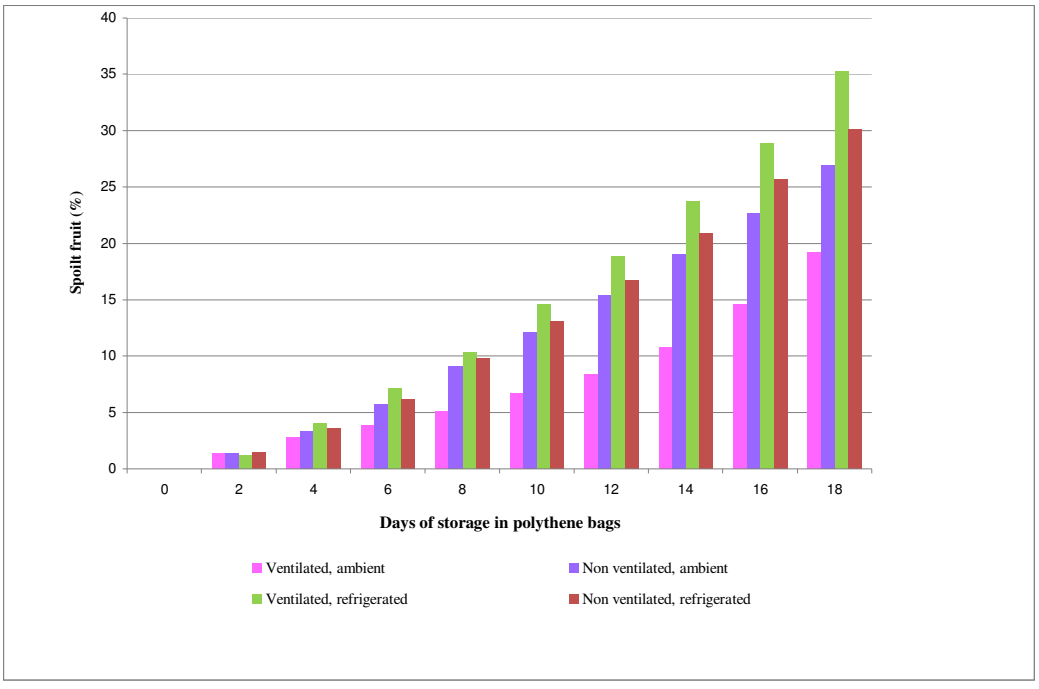


Fig 2b. Influence of ventilation and storage conditions on spoilage of blanched unripe fruits

Table 7. Steeping preservation of green karonda in brine

Week	Brine	
	15 %	20 %
0 day	Dark green, firm with natural sour taste and flavour	Dark green, firm with natural sour taste and flavour
I week	Pale green, firm, unwrinkled smooth surface	Pale green, firm, unwrinkled smooth surface
II week	Fermentation initiated	Fermentation initiated
III week	Fermentative changes with simultaneous release of gases	Acceptable changes in taste and flavour
IV week	Putrefactive changes with unacceptable flavour changes	Acceptable sensory qualities after four weeks of curing

Table 8. Weight of edible ripe karonda fruits (%) as influenced by package and storage treatments at ambient

Days of storage	Unblanched fruits		Mean	Blanched fruits		Mean
	Paper bags			Paper bags		
	Non ventilated	Ventilated		Non ventilated	Ventilated	
0	100.00	100.00	100.00*	100.00	100.00	100.00*
2	93.51	95.00	94.26*	93.60	91.09	93.30*
4	0.00	0.00	0.00*	85.10	84.70	42.45*
6	0.00	0.00	0.00*	0.00	0.00	0.00*
8	0.00	0.00	0.00*	0.00	0.00	0.00*
10	0.00	0.00	0.00*	0.00	0.00	0.00*
Mean	32.25*	32.50*	32.38*	46.45*	45.97*	

*=Significant at P≤ 0.05

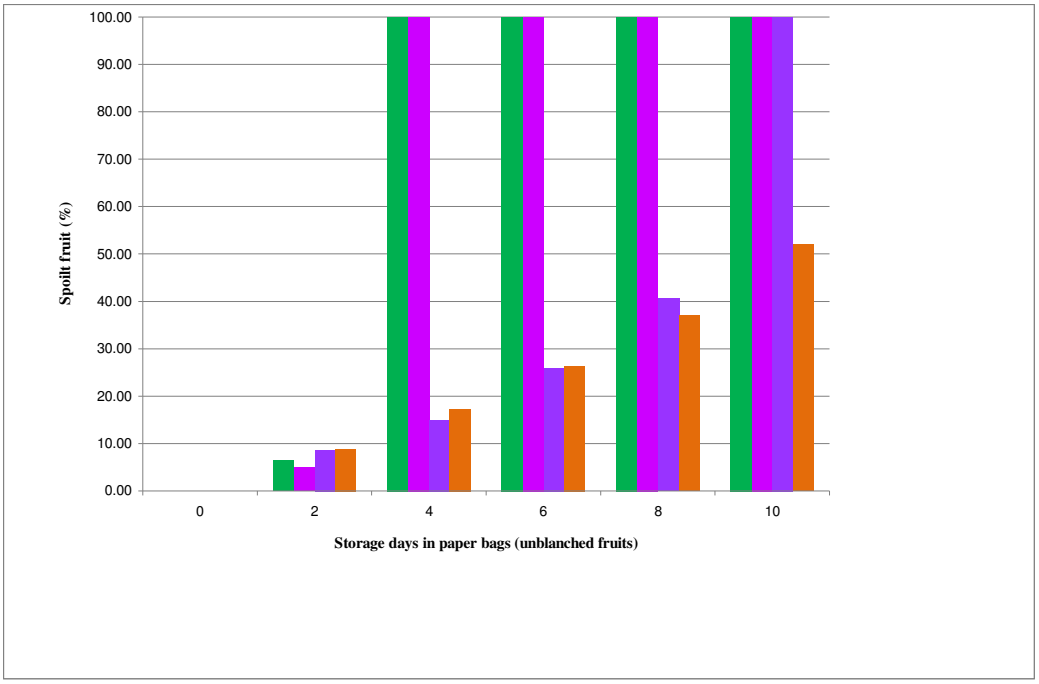
	Sem	CD
Storage days	0.48	1.40
Treatment	0.59	1.72
Storage days X Treatment	1.18	3.43

Table 9. Weight of edible ripe karonda fruits (%) as influenced in paper bags at refrigerated conditions

Days of storage	Unblanched fruits		Mean	Blanched fruits		Mean
	Paper bags			Paper bags		
	Non ventilated	Ventilated		Non ventilated	Ventilated	
0	100.00	100.00	100.00	100.00	100.00	100.00
2	91.23	91.07	91.15*	91.70	89.94	90.99*
4	84.88	82.58	83.73*	84.54	79.64	82.91*
6	73.99	73.62	73.81*	73.48	60.37	70.37*
8	59.35	62.90	61.13*	52.78	31.83	51.72*
10	0.00	48.04	24.02*	0.00	0.00	12.01*
Mean	68.24*	76.37*	72.31*	67.08*	60.30*	68.00*

*=Significant at P≤ 0.05

	Sem	CD
Storage days	0.48	1.40
Treatment	0.59	1.72
Storage days X Treatment	1.18	3.43



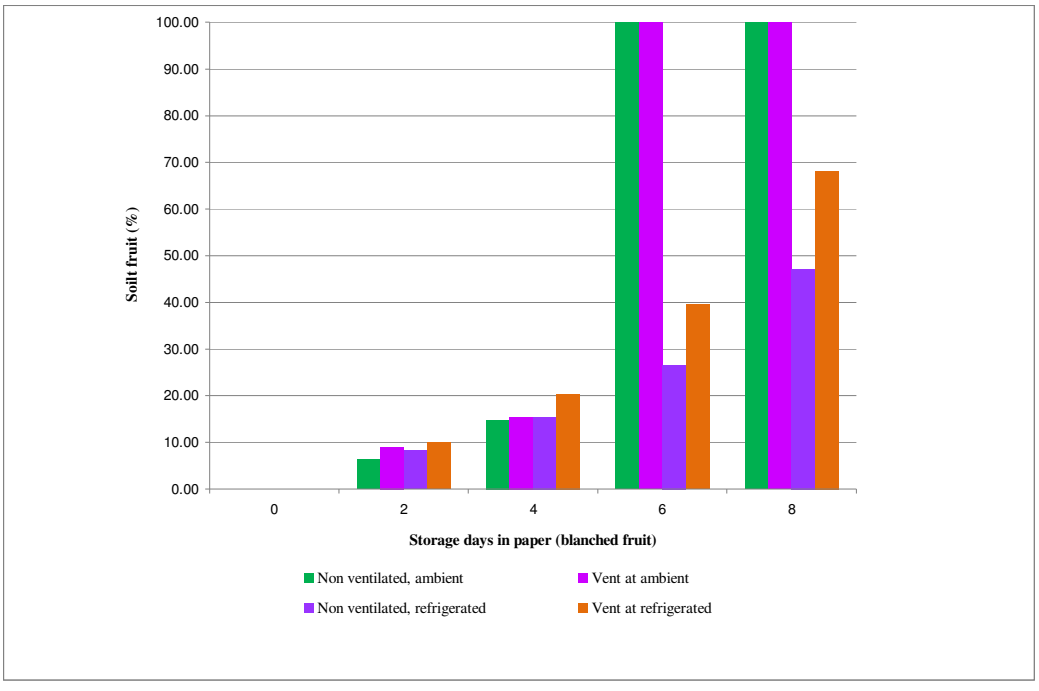


Fig 3b. Influence of ventilation and storage conditions on spoilage of ripe fruits

Weight of the edible fruits of ripe karonda as influenced by package and storage condition stored at refrigerated temperature is presented in Table 9. The edible fruit weight was significantly influence by storage treatments and conditions in paper bags during storage. Among all the four treatments unblanched fruits yielded more edible fruits with lowered loss (Fig 3) at refrigerated condition. The blanched fruits were stored in non-ventilated paper bags exhibited better shelf life. than the fruits stored ventilated paper bags. Resulted in maximum spoilage after 10^{th} day of storage observed in blanched paper bags irrespectively of packaging condition and also observed spoilage in unblanched fruits stored in non ventilated paper bags. Thus at refrigerated condition unblanched fruits stored in ventilated paper bags found to be good shelf life.

4.3 Value addition to karonda

Karonda is a fruit with varying uses and acceptability depending upon stage of maturity. The sour unripe fruits and delicate ripe fruits demand application of suitable value addition technology to extend the shelf life of highly perishable commodity. Results of the value addition trials conducted for preparation of different products using unripe, ripe and cured fruits are presented in this section.

4.3.1 Value addition to unripe karonda

Unripe karonda fruits were explored for value addition to augment utilization and consumption. Results of experiments conducted for development of different value added products such as chutney, powder, glazed green candy and pickles are as follows.

Standardization trials for development of ready to use traditional product chutney were tried out, with varying the proportion of ingredients (Table 10). An attractive well balanced product although could be obtained in the third trial (Table 11) the product exhibited a poor shelf life of 30 days under refrigerated storage. There was a gradual improvement in organoleptic characteristics of the chutney and highest acceptability index of 71.11 was evident at the third level.

Trials were conducted to develop a karonda powder using salt and unripe karonda (Table 12). The shredded fruit pieces when dehydrated at 60 ± 1 º C with varying levels of salt resulted in a less appealing product. The product was coarse and fibrous and exhibited less acceptability when evaluated by the investigating team.

Attempts were made to explore the possibility of proportion of green karonda candies using varying levels and sugar (Table 13). The fruits were steeped in crystal sugar for few days to result osmotic dehydration of the fruits and dissociation of sugar in the first exudates. At the end of first stage, the product was although good in taste, it was sticky and there was a need to improve the handling properties. In second stage the concentration of syrup was increased and curing continued to get appealing fruits but taste and texture were poor. The osmo dried fruits were drained from syrup and coated with the powder sugar to get dry candies with flavour. Hence the process was continued to enhance flavour with addition of cardamom powder. The fruit candies thus obtained were dry and separate but hard in texture. On over all bases the product was less acceptable in taste, flavour and texture.

Different standardization trials were conducted to develop karonda pickle using common traditional methods are presented in Table 14. Suitable variations in salt and chilly powder were made as per the sensory quality evaluation. Addition of salt and chilly powder in 20 and 15 per cent resulted in a product with mean total score of 26.99 and acceptability index of 59.97 (Table 15). The product was poor and therefore a in the second trial proportion of salt and chilly powder were reduced (20 and 10 %, respectively). The product recorded poor acceptability with mean total score of 31.12 and acceptability index of 69.15. Third trial was conducted altering the proportion of ingredients by reducing chilly powder to 8 per cent. Although the sensory quality evaluation scores increased with total scores to 33.37 and acceptability index of 74.15, the product was less appealing as an acceptable pickle. Hence, the experimentation was modified to develop traditional karonda pickle.

Results of the trials conducted for development novel pickle with new ingredients is depicted in Table 16 and Plate 4. The mean scores of sensory evaluation are presented in Table 17.

Table 10. Standardization trials for karonda chutney

Ingredients (g)	I trial	II trial	III trial
Unripe karonda	70	60	50
Green chillies	30	40	50
Jaggery	5	10	20
Curry leaves	1	2	2
Coriander leaves	3	5	5
Cumin seeds	1	1	1
Garlic	1	1	1
Salt	5	5	5
Product profile	Acidic taste and dull in appearance, suggested to improve flavour, taste and texture.	Attractive, acceptable flavour and aroma, but suggested to improve taste.	Attractive, well balanced and acceptable product.
Shelf life at refrigerated condition	30 days	30 days	30 days

Table 11. Mean sensory scores during standardization of karonda chutney

Parameters	Trials				
	I	II	III	F	C.D
Colour and appearance	4.50[a]	4.87[ab]	6.25[b]	9.92*	1.41
Texture	4.00[a]	5.13[ab]	6.25[b]	17.18*	1.36
Taste	4.75[a]	5.38[ab]	6.75[b]	10.42*	1.47
Flavour	3.87[a]	5.25[b]	6.25[b]	23.40*	1.37
Overall acceptability	4.62[a]	5.13[a]	6.50[a]	12.42*	1.37
Mean total score (maximum 45)	24.62	25.50	32.00	-	-
Acceptability Index	54.71	56.66	71.11	-	-

* - Significant at P≤0.05 level, numbers with same superscripts are similar

Table 12. Trials during standardization of karonda powder

Sl. No	Salt (%)	Descriptive profile
1	2	Fibrous, coarse, dark brown, less attractive, sour, need to improvement in texture
2	4	Fibrous, coarse, dark brown, sour, less attractive, need to improve in texture
3	6	Fibrous, coarse, dark brown, sour, can be accepted with improvement in taste and texture
4	8	Fibrous, coarse, dark brown, balanced sour and salty but less accepted
5	10	Fibrous, coarse, dark brown, highly salty and unacceptable

Table 13. Standardization trials for preparation glazed green karonda

Stages	Treatment	Process	Observation	Sensory quality	Remarks
I	Fruits: crystal sugar (5:2)	Cured for 10 days with intermittent shaking.	Sugar dissolved, fruits turned pale green.	Acceptable in appearance and flavor, but acidic taste and sticky, not acceptable	Suggested to improve taste and texture.
II	Sugar concentration increased to 80 per cent	Cured for 5 days with intermittent shaking	Fruity shriveled	Acceptable in taste and appearance but sticky, not acceptable	Suggested to improve texture and flavour.
III	Fruits drained, coated with powdered sugar	Subjected to cabinet dehydration at 60 ± 5 ºC for 24 hours	Partially dried, firm and separate	Acceptable taste and texture dull in appearance, not acceptable	Suggested to improve appearance and flavour
IV	Addition of cardamom powder	Mixing of cardamom powder (1%)	Pale green, firm, separate and semi dry	Acceptable in taste, flavor and texture but dull in appearance, not acceptable	Acceptable in texture flavour and taste, not acceptable

Table 14. Standardization trials for karonda traditional pickle

Ingredients (g)	Trials		
	I	II	III
Karonda	100	100	100
Salt	25.00	20.00	20.00
Chilly powder	15.00	10.00	8.00
Turmeric powder	1.00	1.00	1.00
Product profile	Salty hot and dry products	Hot and dry product	Well balanced taste but dry product and low acceptability

Table 15. Mean sensory scores during standardization trials for traditional karonda pickle.

Parameters	Trials			
	I	II	III	F
Colour and appearance	6.00	6.25	6.00	0.59^{NS}
Texture	5.37	6.75	7.00	2.96^{NS}
Taste	5.12	4.60	5.12	3.24^{NS}
Flavour	5.25	5.50	6.50	1.96^{NS}
Overall acceptability	5.25	5.25	6.63	2.25^{NS}
Mean total score (maximum 45)	26.99	31.12	33.37	-
Acceptability Index	59.97	69.15	74.15	-

NS-Not significant

Table 16. Standardization# trials for novel karonda pickle

Ingredients (g)	Trials		
	I	II	III
Karonda	80	80	80
Green chillies	20	20	20
Salt	25	20	20
Fennel seeds	15	10	6
Descriptive profile of novel karonda pickle	Pronounced fennel flavour	Suggested to reduce fennel seeds	Acceptable in all the sensory attributes

Other ingredients viz., mustard oil, mustard seeds, *Nigella sativa* seeds and chilli powder, remained same

Table 17. Mean sensory scores during standardization trials for novel karonda pickle

Parameters	Trials			F
	I	II	III	
Colour and appearance	7.00	6.00	7.00	0.00^{NS}
Texture	7.00	7.50	6.88	0.55^{NS}
Taste	7.00	7.00	7.50	0.70^{NS}
Flavour	6.38	6.75	6.38	0.51^{NS}
Overall acceptability	7.00	7.25	6.75	0.61^{NS}
Mean total score (maximum 45)	34.38	34.50	34.51	-
Acceptability Index	76.40	76.66	76.68	-

NS-Not significant

Table 18. Effect of storage on sensory characteristics of novel karonda pickle

Parameters	Storage period (months)									F	C.D
	Initial	1	2	3	4	5	6	7	8		
Colour and appearance	6.75	6.33	6.22	5.78	6.25	6.25	6.38	6.25	6.13	0.55^{NS}	-
Texture	7.00	6.33	6.00	6.11	5.88	5.75	5.75	5.63	5.50	2.02^{NS}	-
Taste	6.50^{a}	6.56^{a}	6.44^{a}	6.33^{a}	6.25^{a}	5.75^{b}	6.00^{a}	5.88^{b}	5.75^{b}	2.99^{*}	1.2
Flavour	6.50	6.22	6.22	6.62	6.13	6.50	6.25	6.13	6.13	0.86^{NS}	-
Overall acceptability	6.63	6.22	6.22	6.22	6.13	6.38	6.13	6.13	6.13	0.85^{NS}	-
Mean total score (maximum 45)	33.38	31.66	31.10	30.66	30.64	30.63	30.51	30.02	29.64	-	-
Acceptability Index	74.17	70.35	69.11	68.13	68.08	68.06	67.80	66.71	65.86	-	-

* Significant at P≤0.05 NS-Not significant Means with different superscripts in the same column are significantly different

The proportion of novel pickle with chillies and fennel seeds along with other ingredients resulted in a product which possessed pronounced fennel flavor and salty taste. The mean total score was 34.38 with an acceptability index of 76.40. Second trial for the novel product was carried out reducing the proportion of fennel and salt, which resulted in a product with an acceptability index of 76.66 with mean total score of 34.50. Another trial was conducted as per the suggestions of sensory panel by reducing fennel seeds which resulted in an acceptable well balanced product with total mean sensory score of 34.51 and acceptability index of 76.68. Thus the sensory scores from product did not vary significantly and all were acceptable.

4.3.1. Effect of storage sensory on quality of novel pickle.

The results of the studies conducted to evaluate the effect of storage on the sensory attributes of novel karonda pickle were presented in Table 18. It was observed that storage exerted no significant deleterious effects on colour and appearance of pickle even after 8 months of storage. The sensory evaluation indicated highest scores of 6.75 initially and the scores decreased gradually to 6.13 at the end of 8 month storage period. However, the decrease in sensory scores for colour and appearance were not significant. With regard to texture, sensory scores decreased non significantly as the storage duration increased. The novel pickle initially recorded a mean score of 7.00, which reduced gradually to 5.50 at the end of storage period of 8 months. The reduction however was non significant. With regard to taste, the mean score at the beginning of storage was 6.50, decreased significantly with the progress in storage duration to 5.75 at the end of the storage period of 8th month. The mean for flavour was initially was 6.50, but reduced to 6.13 at the 8th month of storage duration, gradually. However the reduction in score was not significant. Similar trend was observed with overall acceptability of the novel pickle. The mean score was 6.63 at the initial month but gradual non significant reduction was recorded at the end of storage period to 6.13. The total mean score for the product as evaluated by the semi trained sensory panel was 33.38 with an acceptability index of 74.17 in the beginning of the storage experiments, was observed. There was a gradual reduction in total mean score to 29.64 and acceptability index to 65.86 after storage. However the change was not significant. Thus the sensory evaluation results revealed that novel karonda pickle was acceptable in all the sensory characteristics up to the storage period of 8 months.

4.3.2 Effect of curing karonda on pickle quality

It is a practice to cure fruits in salt prior to pickling. Results of the trials conducted to pickle cured karonda are presented in Table 19, and an effect of curing treatments on pickle preparation is presented in Tables 20 and 21. The product recorded highly acceptable colour, appearance, texture, taste, flavour and over all acceptability with scores more than 7.00 for all attributes, in all the trials. The mean total scores for the product ranged between 36.27 with first trial to 36.89 in the third trial. The acceptability indices of the products were between 80.60 in the first trial to 81.97 in the third trial. Thus the product was highly acceptable.

The karonda pickle prepared from cured fruits was subjected to storage quality evaluation in terms of visual observation and sensory quality parameters. Results of the sensory quality evaluation upon storage are presented in Table 21. It was observed that acceptability increased gradually as indicated by the mean sensory scores during storage period of 7 month. However, the values were statistically non significant. Thus trend was observed with respect to colour and appearance, Texture, taste, flavour and over all acceptability. Simultaneous increments also recorded in mean total score and mean acceptability indices during storage duration.

4.4 Value addition to ripe karonda

Ripe karonda fruits are delicate, more prone to bruises and surface damage than the unripe fruits. The fruit pulp exhibited adorable pink pulp and possessed sourish sweet taste exploited for value addition. Results different trials conducted to develop beverages such as squash, nectar and ready to serve beverages with ripe karonda are summarized in Table 22. The results indicated unsatisfactory product profile with respect to colour, appearance and taste. Although fruity flavor of karonda was perceptible, the squash and nectar were not highly impressive in sensory appeal.

Table 19. Trials for standardization# of novel karonda pickle with cured fruits

Ingredients (g)	Trials		
	I	II	III
Karonda	80	80	80
Green chillies	20	20	20
Salt	20	20	20
Fennel seeds	15	10	6
Sugar	-	-	5
Descriptive profile of novel karonda pickle	Pronounced fennel flavour	Suggested to reduce fennel seeds	Acceptable in all the sensory attributes

Other ingredients viz., mustard oil, mustard seeds, *Nigella sativa* seeds and chilli powder remained same.

Table 20. Mean sensory scores during standardization of karonda pickle with cured fruits

Parameters	Trials			F
	I	II	III	
Colour and appearance	7.13	7.25	7.38	0.18^{NS}
Texture	7.13	7.38	7.50	0.57^{NS}
Taste	7.25	7.50	7.38	0.28^{NS}
Flavour	7.13	7.13	7.25	0.05^{NS}
Overall acceptability	7.63	7.50	7.38	0.19^{NS}
Mean total score (maximum 45)	36.27	36.76	36.89	-
Acceptability Index	80.60	81.68	81.97	-

NS-Not significant

Table 21. Effect of storage on sensory characteristics of novel pickle with cured karonda

Parameters	Storage period (months)								F
	Initial	1	2	3	4	5	6	7	
Colour and appearance	6.88	7.13	7.75	7.63	7.75	7.88	7.88	8.00	0.90^{NS}
Texture	6.88	7.13	7.13	7.50	7.88	8.00	8.13	7.88	1.20^{NS}
Taste	7.25	7.38	7.63	8.13	7.88	7.88	8.00	8.00	0.66^{NS}
Flavour	6.75	7.3	7.25	7.25	7.75	7.88	8.00	8.13	1.26^{NS}
Overall acceptability	6.63	7.00	7.38	7.38	7.75	7.88	7.88	8.00	1.27^{NS}
Mean total score (maximum 45)	34.39	35.94	37.14	37.89	39.01	39.52	39.82	40.01	-
Acceptability Index	76.42	79.86	82.53	84.20	86.68	87.82	88.64	88.91	-

NS-Not significant

Table 22. Trials for preparation of karonda beverages with ripe fruits

Ingredients(g)	Squash	Nectar	RTS
Karonda	100	200	250
Sugar	60	225	227
Citric acid	0.4	0.3	1.0
Water	130	100	-
Dilution	1:3	1:3	-
pH	4.00	3.38	3.55
Storage quality evaluation	Product deterioration after 20 days, pH increased to 4.25	Product deteriorated after one month of storage, pH reduced to 4.00	Fermentation spoilage after one month, pH increased to 4.55
Product profile	Light brown with light pink shade, less attractive, acceptable sweetness, fruity karonda flavor, insipid needs to be improved	Pinkish light brown, less transparent, acceptable sweetness, insipid, fruity flavor, aromatic, good, needs to be improved	Pinkish brown, less attractive, acceptable sweetness, fruity karonda flavor, well balanced beverage

Plate 3.Karonda Rts beverage, nectar and squash

Table 23. Standardization trials for preparation of karonda candy

Stages	Treatment	Process	Observation	Sensory quality	Remarks
I	Ripe fruits and crystal sugar placed in airtight glass jar	Cured for 5 days with intermittent shaking, resulted in osmosis	Sugar dissolved in the liberated juice fruits turned pale purple colour	Acceptable in taste and flavour, but sticky and wrinkled	Improvement in taste and texture need to be improved
II	Added 100g of sugar to improve the concentration to 80 percent coated	Cured for 3 days with intermittent shaking	Fruits were reduced in size semi dry	Fruits were acceptable in appearance but sticky and moist.	Suggested to improve taste and texture
III	Coated powdered sugar (100g) to the drained fruits	Fruits subjected to cabinet dehydration at 60 ± 5 □C for 24 hours	Fruits were dried, hard and separate dull in colour (pale purple)	Acceptable in taste	Suggested to improve taste, texture and flavour
IV	Addition of cardamom powder (1%)	Mixing cardamom powder	No change in fruits, dry, separated and hard	Fruits were acceptable in taste and flavour	Less acceptable in taste & flavour but poor in texture.

Table 24. Standardization trials for preparation of jam with wild karonda

Ingredients (%)	Trials	
	I	II
Karonda	100	100
Apple	0	35
Sugar	50	50
Citric acid	0.1	0.1
Test for pectin in extract	Poor, granular	Moderate, small lumps
Descriptive product profile	Dark caramel brown colour, very poor set, sticky and rejected	Dark reddish brown, poor set, good in taste, sticky and not acceptable

Table 25. Morphological characteristics of improved variety of karonda

Characteristics	Unripe	Ripe
Morphology	Drupe, globose to broad ovoid firm thick smooth skin	Drupe, globose to broad ovoid, lightly firm, thick, smooth skin
Colour	Light green with pink blush	Lustrous dark purple and attractive
Weight (g/fruit)	2.79	3.39
Pulp weight (g/ fruit)	2.48	2.71
Pulp colour	Creamish pale green	Dark pink
Seed weight (g/fruit)	0.31	0.68
Seed number/ fruit	5-6	5-6
Volume (ml/fruit)	3.60	3.20
Density (g/ml)	0.77	1.05
Length (cm)	2.30	2.10
Width (cm)	1.75	1.50
Fruit colour	Light green	Dark purple

The RTS beverage was pinkish brown, attractive with acceptable sensory attributes to the investigators (Plate 3). The beverages recorded pH of 4.00, 3.38 and 3.55 in squash, nectar and RTS, respectively.

Standardization trials carried out to develop fruit candies with ripe karonda is presented Table 23. The fruits were steeped in crystal sugar for few days to result in osmotic dehydration of the fruits and dissolution of sugar in the fruit exudates. At the end of first stage, the product was although good in taste, it was sticky and there was a need to improve the handling properties. In second stage the concentration of syrup was increased and curing continued to get appealing fruit candies but taste and texture were poor. The osmo dried fruits were drained from syrup and coated with the powder sugar to get dry candies with flavor. Hence the process was continued to enhance flavour with addition of cardamom powder. The fruit candies thus obtained were dry and separate but hard in texture. On over all bases the product was less acceptable in taste, flavor and texture.

Results of the trials conducted for development of karonda jam is presented in Table 24. In the first trial the jam was prepared solely with karonda fruits, along with 0.1 per cent of citric acid. The product thus obtained was dark caramel brown colour, very sticky, poorly set and not acceptable. In the second trial conducted with addition of 35 per cent apple and 0.1 per cent of citric acid resulted in a product was dark reddish brown, poorly set, sticky, found small lumps and rejected. Thus the wild karonda fruits were not suitable for jam preparation.

4.5 Value addition to improved karonda selection.

Morphological characteristics of improved variety of karonda selection are presented in Table 25. Karonda being a drupe was found to be light green with pink blush, broad ovoid, firm, thick and smooth skin when unripe (Fig 1). The ripe fruits were lustrous dark purple and attractive with broad ovoid, lightly firm, thick and smooth skin. The mean fruit weight was 2.79 g/fruit when unripe but ripe fruit weighed was 3.39 g/fruit. The pulp weight was 2.48 g and 2.71 g/fruit in unripe and ripe fruits, respectively. The unripe fruits exhibited creamish pale green pulp, while the ripe fruit pulp was dark pink with 5 to 6 seeds in each fruit. The mean volume of unripe fruits was 3.60 ml/fruit as against 3.20 ml/fruit in ripe fruits. The mean length and width of unripe and ripe karonda were 2.30, 2.10 cm and 1.75, 1.50 cm, respectively. The density of unripe fruits was 0.77 g/ml and in ripe fruits it was 1.05 g/ml. Thus variation in morphological character was evident.

Utilization of improved variety of karonda is specific to its stage of maturity. (Table 26) the unripe fruits being acidic and slightly bitter in taste were not consumable as table fruit, although traditionally processed in to pickle. The unripe fruits were firm seeds and edible portion was 88.00 per cent, excluding the seeds. Handling unripe fruits was found to be easy and could be stored for 8 to 10 days without any significant changes in quality characteristics. The ripe fruits were handle easily, storable for 3 to 4 days at ambient condition, fruits are sour with pronounced bitter taste, fruits were not consumable with as such with edible portion ofn79.00 per cent.

Results of the trials conducted for development of karonda jam is presented in Table 27, and the mean sensory scores are indicated in Table 28. First and second trials were made by using wild karonda fruits. The results of the experiments were unsuccessful. Therefore the preparation of jam with improved variety of karonda fruits along with apple (60:40) and 0.1 per cent of citric acid was carried out. It was observed that the product was attractive purplish red, poorly set, acceptable in sweet and flavour but suggested to improve in taste and texture with the mean total sensory scores of 35.23, acceptability index of 78.28. Fourth trial conducted with the variation in the proportion of citric acid (0.5 %), observed that it was very attractive, poorly set, moderate small lumps were found, less acceptable flavour and panel suggested to improve taste by reducing acidity with the mean total score of 33.12 and decreased acceptability index of 73.60. Reduction in the acidity by reducing citric acid (0.25 %) content was observed. The product containing 50:50 (karonda: apple) exhibited attractive purplish red, well set, balanced in taste and flavour and highly acceptable jam (Plate 5). The mean total score and acceptability index were 32.74 and 72.75, respectively. Although the mean scores were lower than the values indicated third trails they were not significant (Table 28).

Table 26. Characterization of improved karonda for sensory attributes and edibility

Characteristics	Unripe	Ripe
Taste and flavour	Acidic and slightly bitter	Sour with pronounced bitter taste.
Texture	Firm seeds	Slightly firm
Edibility	Fruit not consumable as such but whole fruit is used for processing	Fruit not consumable as such need to be explored for value addition
Edible portion (%)	88.00	79.00
Handling properties at ambient	Easy, no special care storable for 8 to 10 days	Firm storable for 3 to 4 days
Traditional uses	Processed in to pickle	Not consumable

Table 27. Trials during standardization of karonda jam

Ingredients (g)	Trials			
	II	III	IV	V
Karonda	60	60	60	50
apple	35	40	40	50
Sugar	50	50	50	50
Citric acid	0.1	0.1	0.5	0.25
Descriptive product profile	Attractive purplish red, poorly set, very sweet, flavour, acceptable but improvement for taste suggested	Attractive purplish red, poorly set, very sweet, flavour, acceptable but improvement for taste suggested	Very attractive purplish red, poor set very sour, less acceptable flavour, suggested to improve taste by reducing acidity	Very attractive purplish red, well set, balanced in taste and flavour and highly acceptable.
Test for pectin in extract	Moderate, small lumps	Moderate, small lumps	Moderate, small lumps	Good, big lumps
pH	3.60	3.95	4.25	4.40
Storage quality evaluation	Product deterioration after 20 days, pH increased to 4.25	Product deteriorated after one month of storage, pH reduced to 4.00	Fermentation spoilage after one month, pH increased to 4.55	Storage quality evaluation

Table 28. Mean sensory scores during standardization of jam with cultivated karonda

Parameters	Trials			
	III	IV	V	F
Colour and appearance	7.37	6.37	6.62	2.58^{NS}
Consistency	6.62	6.50	6.25	0.24^{NS}
Taste	7.37	7.00	6.62	1.08^{NS}
Flavour	6.87	6.50	6.50	0.31^{NS}
Overall acceptability	6.22	6.75	6.75	0.18^{NS}
Mean total score (maximum 45)	35.23	33.12	32.74	-
Acceptability Index	78.28	73.60	72.75	-

NS-Not significant

Table 29. Effect of storage on sensory characteristics of karonda jam

Parameters	Storage period (months)								
	Initial	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**F**
Colour and appearance	6.56	6.50	7.13	6.38	6.63	7.13	7.13	6.25	1.39^{NS}
Texture	5.89	6.75	7.00	6.50	6.25	6.63	6.50	6.25	0.42^{NS}
Taste	6.56	7.13	7.25	7.00	6.63	7.13	6.38	6.38	0.96^{NS}
Flavour	6.11	6.88	6.88	6.50	6.50	6.50	6.25	6.25	0.43^{NS}
Overall acceptability	6.22	6.75	6.88	6.75	6.75	6.63	6.63	6.63	0.13^{NS}
Mean total score (maximum 45)	31.34	34.01	35.14	33.13	32.76	34.02	32.09	31.76	-
Acceptability Index	69.64	75.57	78.08	73.62	72.80	75.60	73.08	70.57	-

NS-Not significant

Table 30. Consumer acceptability of karonda pickle by FACT scale

Scores	Students	House wives (%)	Working class (%)	Total (%)
I would eat this every opportunity that I had	21	5	10	36 (22.5)
I would eat this pickle very often	14	3	8	25 (15.62)
I would frequently eat this pickle	5	2	4	11 (6.87)
I like this and eat it now and then	23	11	22	56 (35)
I would eat this if available but would not go out of my way	10	3	4	20 (12.5)
I don't like this but would eat this on an occasion	-	-	-	-
I would hardly ever eat this pickle	1	2	4	7 (4.37)
I would eat this if there were no other food choices	-	1	2	3 (1.87)
I would eat this only if forced	2	-	-	2 (1.25)
Total	76 (47.5)	27 (16.87)	57 (35.62)	160

Table 31. Acceptability of value added karonda products

Products	Karonda	Mean total score (Max 45)	Acceptability index	Ranking
Cured fruits pickle	Un ripe	36.80	81.97	I
Fresh fruit pickle	Un ripe	34.51	76.68	II
Traditional pickle	Un ripe	33.37	74.15	III
Jam	Ripe	32.74	72.75	IV
Chutney	Unripe	32.00	71.11	V
Fruit beverages	Ripe	Not acceptable	-	-
Candies	Both	Not acceptable	-	-
Powder	Unripe	Not acceptable	-	-

Storage quality evaluation of jam was carried out at ambient. Effect of the storage on sensory attributes of jam is presented in Table 29, it was observed that there was no significant effect on colour and appearance, initially it was recorded 6.56 and the scores, increased gradually to 7.13 at the end of sixth month storage period. However, it was decreased to 6.25 at the end of storage period of seventh month. With respect to texture, sensory scores increased up to second month of storage (7.00), further decreased to 6.50 in third month of storage gradually decreased to 6.25. However the reduction in score was not significant. With regard to taste initially it was 6.56, increased up to 7.13 in fifth month of storage, further it was reduced to 6.38 at the end of storage. Scores were not effect significantly. Mean sensory scores for flavour observed that there was increased at second and third month of storage and further it was decreased to 6.25 at the end of seventh month of storage. Mean scores were not significantly decreased at the end of storage period. Similar trend was observed with over all acceptability mean scores was observed in jam. The mean score was initially 6.22, increased mean scores were observed in second month of storage gradually it was decreased to 6.63 at the end of seventh month non significantly. It was observed that the pH of the value added jam decreased gradually with increasing storage period.

Consumer acceptability of karonda pickle was conducted among the students, house wives/women and staff of University of Agricultural Sciences Dharwad campus using FACT scale and the results is depicted in Table 30. The consumer acceptability survey revealed that majority of the subjects (35 %) indicated that they would like to eat this now and then. It was also observed that 22.50 per cent of consumers liked it extremely and expressed that they would like to eat this at every opportunity given. However 15.62 per cent the consumer mentioned that they would like to eat this pickle very often. It was indicated that 12.50 per cent of consumers would eat this if available but not try to get it out of way however, few of the consumers did not like the product (7.49 %). However on overall basis the pickles processed either by novel or traditional methods were highly acceptable which depicted in Table 31. Among the value added foods based on ripe karonda although jam scored highest, comparatively the pickles were superior to it.

Thus the study revealed that shelf life karonda a highly perishable fruit could be extended for a week by storing the fruits in paper bags at ambient and at refrigeration the polythene bags were better in retaining higher per cent of fruit weight. However steeping in 20 per cent brine was effective in extending the storability for pickling process. Unripe fruits could be successfully processed in to acceptable chutney and pickles. The pickle was highly acceptable and the pickles prepared with brine steeped fruits were highly accepted. The ripe fruits of karonda selection could be processed in to a delicious blend jam. The value added products exhibited excellent shelf life of more than six months without the use of any synthetic additives. Thus the study deduced important techniques for shelf life extension and value addition to karonda.

5. DISCUSSION

Diverse agro climatic regions and wide variety of soils have placed India in a prominent position on the pomological map of the world. Various types of cultivated major fruits and minor fruits growing wild are available in abundance in different seasons all over India. Despite being endowed with several nutrients, phytochemicals and therapeutic components and also being a source of livelihood for the people dependent on forests, the minor fruits have remained in the background. Also the availability of major fruits in plentiful have limited the scope for expansion of minor fruits (Gajanan, *et. al*., 2010). Most of the minor fruits are often available only locally and are practically unknown in other parts of the world. Many of these fruits can be grown under adverse conditions and because they possess nutritive and therapeutic components can satisfy the demands of the health conscious consumers. Recognising the importance of indigenous fruits FAO has suggested them to be essential for food security, health, social and economic welfare of rural communities.

Attempts are being made to identify and promote indigenous priority fruits for cultivation and consumption for multifaceted benefits bestowed on soil and human health. Hence there is a need to exploit karonda for health benefits. The plant bears fruits which can be explored for value addition. The plant is xerophyte, growing in a broad range of climatic conditions, such as dry deserts to cooler terrains of mountains either as bush or a rambling wine depending upon the species (Plate 1 and 2). It has been reported that whole plant or its parts are used for curing asthma, rheumatism, diabetes, paralysis, toothache, as anthelmintic, anti allergic, snake bite antidote, etc. Roots of Capparis species are used in treatment of particular ailments like tuberculosis, cancer, rheumatism or diabetes, which still requires extensive studies. The fruits are used in pickle production. Detailed review of significance of *Capparis* species on medicinal and food value has been reported by (Mishra *et. al*., 2007). Being harsh terrain species the plant has been suggested to be considered for greening the environment.

Recognising the importance of karonda in food applications a study was conducted to explore the value addition potentials of the seasonal which are available abundantly, but perishable easily. Results of the present study are discussed on following paragraphs.

5.1 Physical parameters of karonda

Physical and morphological parameters influence the acceptability of any food by the consumers. Attractive morphological parameters with appealing sensory characters and chemical components positively influence the acceptability. Fruit size affects handling during processing and in extending the holding time of fruits.

Studies conducted to evaluate physico-chemical characteristics, shelf life of unripe and ripe karonda collected from the wild the cultivated farm sample indicated variations in physicochemical characteristics (Tables 2, 3, 4 and 25). In the present investigation the fruits collected from the wild were smaller in size than the farm cultivated fruits. Variation in colour was also observed in both unripe and unripe fruits of karonda. Similar morphological characteristics of karonda were observed by Nalini and Chimmad (2005a and b and Bharadwaj and Yamadagni, 2003). A study conducted by Singh *et al*. (2006) revealed variation in morphology of ten different accession of karonda collected from Karnataka, Andhra Pradesh, Rajasthan, Madhya Pradesh and Uttar Pradesh. The colour varied from white with pink blush to purple almost black. The fruit height was much higher of 1.85 to 6.00 and length was 0.90 to 2.40 cm, diameter from 0.32 to 2.15 cm, seed weight from 0.26 to 1.40 g and pulp content from 1.35 to 4.67 g, difference could be due to geographic variations such similar locational variation in fruit weight was indicated in garcenia and mango fruits of different forests of Uttara Kannada district, Karnataka (Nalini and Chimmad 2005 a and b). In the present investigation also the cultivated fruits of karonda selection were bigger than those collected from the wild (Table 24). The ripe fruits farm cultivated selections were bigger and firmer than the wild fruit samples.

The chemical composition of karonda varied due to stage of ripening and the total mineral matter was around 10 per cent, such values were also reported by Awasthi *et al*. (1986) in karonda. Ascorbic content was a low 17.00 mg in ripe and a high of 48.00 mg in ripe karonda (Table 3).

Such trend was also indicated by Manivasagan *et al.* 2006 a. This was attributed with regard to mineral composition, karonda recorded comparable values with other minor fruits. Micronutrients such as potassium (31.25 and 84.20 mg/100g), zinc (1.44 and 5.83 mg/100 g), copper (1.09 and 2.05 mg/100 g), iron (0.83 and 13.90 mg/100 g) and manganese (1.15 and 0.93 mg/100 g) in unripe and ripe fruit, respectively were in line with other minor fruits such as African star apple, Chinese water chest nut, bilimbi and carambola (Chauhan *et al*., 1986; Nwadinigwe, 1982 and Naik *et al*. 2003).

5.2 Storage quality of karonda

The results of the studies for evaluation of ripe and unripe karonda in non ventilated and ventilated paper bags and polythene covers at ambient and refrigerated storage condition in unblanched and blanched fruits is presented in Table 5 to 9 The storability of fruits was assessed in terms of edible fruit weight retained after discarding the fruits infested, spoilt or decayed. It was observed that the storage conditions significantly influenced the storage quality of fruits (Fig. 1 to 3). On overall basis around 80 per cent of unblanched fruit weight was retained up to 8 days of storage in paper bags and non ventilated at ambient. The blanched fruits could be stored better in paper bags and the polythene pouches were not effective in extending the shelf life. This could be due to the moisture accumulation by transformation process, there by initiating spoilage.

However, with respect to storage of unripe fruits in refrigerated condition, all the packaging treatments were helpful in retaining more than 90 per cent of edible fruit weight in unblanched fruits, ventilated packages were significantly superior to non ventilated packages in refrigerated storage condition.

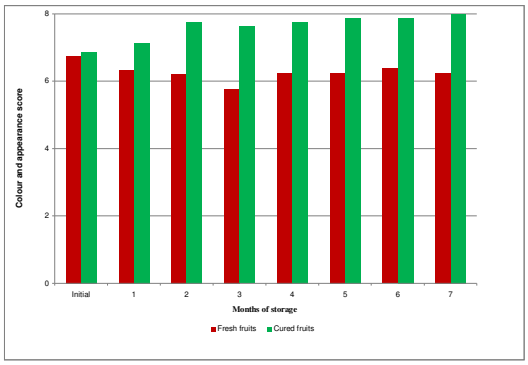
5.3 Value addition to unripe karonda

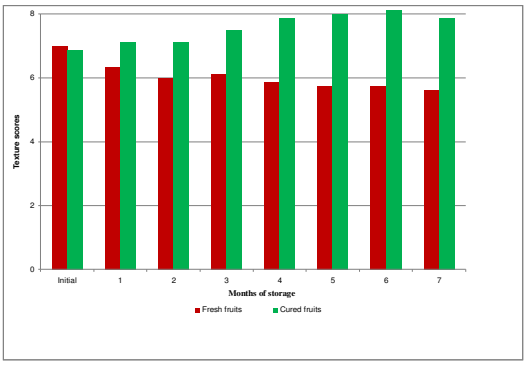
Karonda is a seasonal fruit available in short span of only 2 to 3 months in a year including fruit set stage to ripeness to senescence. Traditional uses for the unripe karonda in form of pickle have been documented by several investigators (Haware and Rao 1979; Panwar, 1996 and Manivasagan *et. al*., 2007).

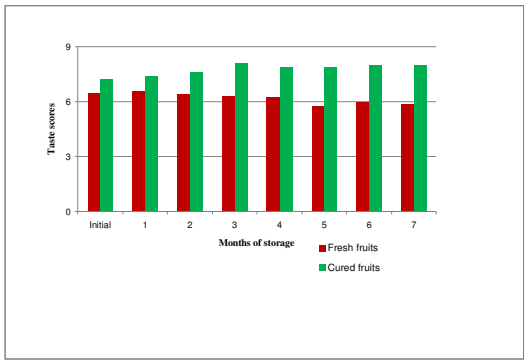
However, in the local area unripe karonda is also used in preparation of food accompaniments in the form of chutney. Trials conducted to assess the sensory quality of karonda chutney (Table 10) although revealed encouraging results, the product exhibited edible qualities for less than one week even under refrigerated storage condition. The fresh chutney exhibited good acceptability index of 71.11 (Table 11). Similar observation has been made by Manivasagan *et al*. (2006 b) that mature unripe karonda could be ideal for making chutneys. The perishability of chutney observed in the present investigation could be attributed to microbial contamination alongside favourable substrates in the product could trigger the spoilage. Hence potentials of dehydrating unripe karonda as an acidulant were explored using varying salt concentration (Table 12). The experimentation resulted in a product that was fibrous, coarse with dark brown colour which was unappealing and could not be considered as an acidulant or for consumption as such. The coarse textural fibrous product could be done to the soft chewy seeds of the fruits which were not revealed in preparation of powder. The fruit comprise of only 80 per cent edible portion (Table 4), remaining 20 per cent seeds as inedible portion could have contributed to the fibrous texture of the powder. Besides, though the fresh fruits were very sour and tart the dehydration process reduced the sourness which could be due to oxidation of acids, or due to low sensory perception of sourness in the dry powder compared to moist juicy fresh fruits.

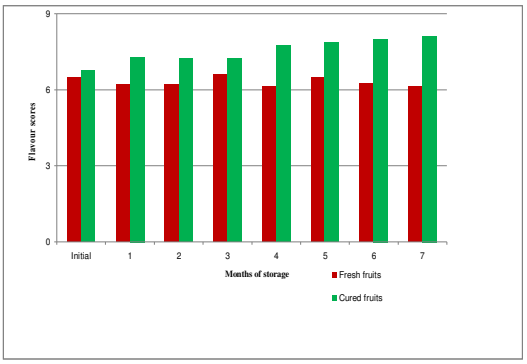
Natal plum (*Carissa grandiflora)* belongs to Apocynacae family to which karonda also belongs. Natal plum is used in the preparation of cherries as glazed fruits with immense food applications in confectionary industry. Hence experimentations were conducted to prepare glazed karonda with unripe fruits by varying treatment combinations at different stages as indicated in Table 13. Irrespective of the attempts conducted in curing fruits in sugar for a prolonged period of ten days, initially and for four days in the subsequent stage, the osmotic dehydration did not result in optimum and ideal fruit candy characters at all stages. This could be again due to the lower pulp proportion in the fruit (Table 2). Attempts to prepare candies with soft seeded fruits of Averrohaea viz., bilimbi and carambola were indicated to result in less acceptable products (Banahatti *et. al.,* 2003). Hence the present study indicated that the species of Carissa was inappropriate for preparation of glazed fruits.

Plate 4. Karonda Pickle Preparation and samples









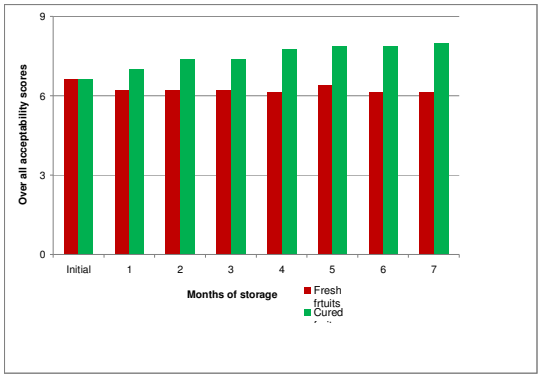


Fig. 4. Effect of storage on sensory characteristics of novel

Therefore the value addition trials were centred on pickling process, a procedure commonly employed by the local population.

Pickling is an age old process of value addition directed to extend the food value by enhancing shelf life besides the altering the sensory properties and economic value. Hence unripe karonda was subjected to pickling using traditional local recipe (Table14). The product was well balanced in sensory attributes and although recorded the acceptability index of 74.15 which is indicated in Table 15. The product was less juicy hence a new recipe with novel ingredients such as *kalunji* seeds (*Nigella sativa*) was attempted in the subsequent value addition trials (Table 16). The attempt resulted in a product that was acceptable in appearance, taste, flavour, texture and overall acceptability with an acceptability index of 76.68 (Table 17). Inclusion of green chillies enhanced visual appearance (Plate 4) besides adding taste, flavour and textural contrast to the product. Fennel and *kalunji* seeds although were added in small proportions contributed to enhancement of taste and flavour. *Kalounji* is although commonly used in north India in food preparation it is relatively a new ingredient in the local area and especially in pickle preparation. Similarly fennel seeds although consumed as mouth freshener and recognised for its digestive properties, the inclusion in pickle was a new way of achieving taste and flavour enhancement in pickling.

The novel pickle with novel ingredients exhibited excellent shelf life at ambient without any significant changes in sensory attributes for six months (Table 18 and Fig. 4). Although there was slight reduction in scores for taste beyond sixth month, the product exhibited good acceptability; despite gradual reduction in acceptability indices from an initial 74.70 to 65.86 at the end of storage period.

Pickle prepared with cured karonda recorded better sensory acceptability than the fresh fruits pickle. Curing enhanced the sensory parameters (Table 21). Similar shelf life of karonda pickle was also reported to be stored for eight months at ambient temperatures around 25 to 30 ºC. In the present study also similar shelf life of the two types of pickles (fresh and cured fruit pickles) was observed, due to browning. The acidic and firm nature of fruits did exert beneficial effects on the preservative quality and also a sensory profile in the current experiments. Manivasagan (2007) also revealed shelf life of 120 days in green and pink karonda with and without seeds. It was indicated that the pickles recorded a decrease in pH, acidity, ascorbic acid and also sensory quality. The browning index was reported to increase and such phenomenon was also observed in the acceptability parameters. Consumer acceptability study indicated encouraging results for the product (Table 30).

The cured karonda pickle was firm, lustrous and attractive. The fruits were juicy and the taste was well blended and the product was relatively juicier, resulting in better sensory parameters in terms of acceptability index than the uncured karonda pickle (Fig 5). Similar effects of curing resulting in better product profile was also recorded by Lal *et al*. (1986) in preservation of fruits and Reddy and Chikkasubbanna (2009) in amla pickles. Enhanced acceptability could be due to the balancing and masking of acidity with absorption of salt during curing process by osmosis process. This was also reported in ker (*Capparis ovata)* where in the fruits cured 15 per cent brine for 20 to 25 days were better in organoleptic parameters by Ozacus (1999). The present investigation also revealed similar phenomenon.

5.4 Value addition to ripe Karonda

Ripe karonda is a sourish sweet fruit with attractive colour and appealing flavour. Value addition experiments revealed interesting results. The trials conducted to prepared beverage such as squash, nectar and RTS beverages with ripe karonda revealed the products to be less acceptable with respect to colour, appearance and taste, despite perceptible fruity flavour of karonda (Plate 3). The products lacked the sour taste and did not exhibit potential for large scale production .This might be due to the lower proportion pulp in relation to seed (Table 2 and 4). The ripe fruits although recorded edible portion of 80.00 per cent, preparation of beverage would not be a better option because during the process of extraction of juice from ripe karonda at least around 30 to 35 percent of fruit pomace is discarded in the form of skin and seeds. The low acceptability could also be due to the reason that synthetic colours or additives were avoided during the process of preparation of beverages of all types.

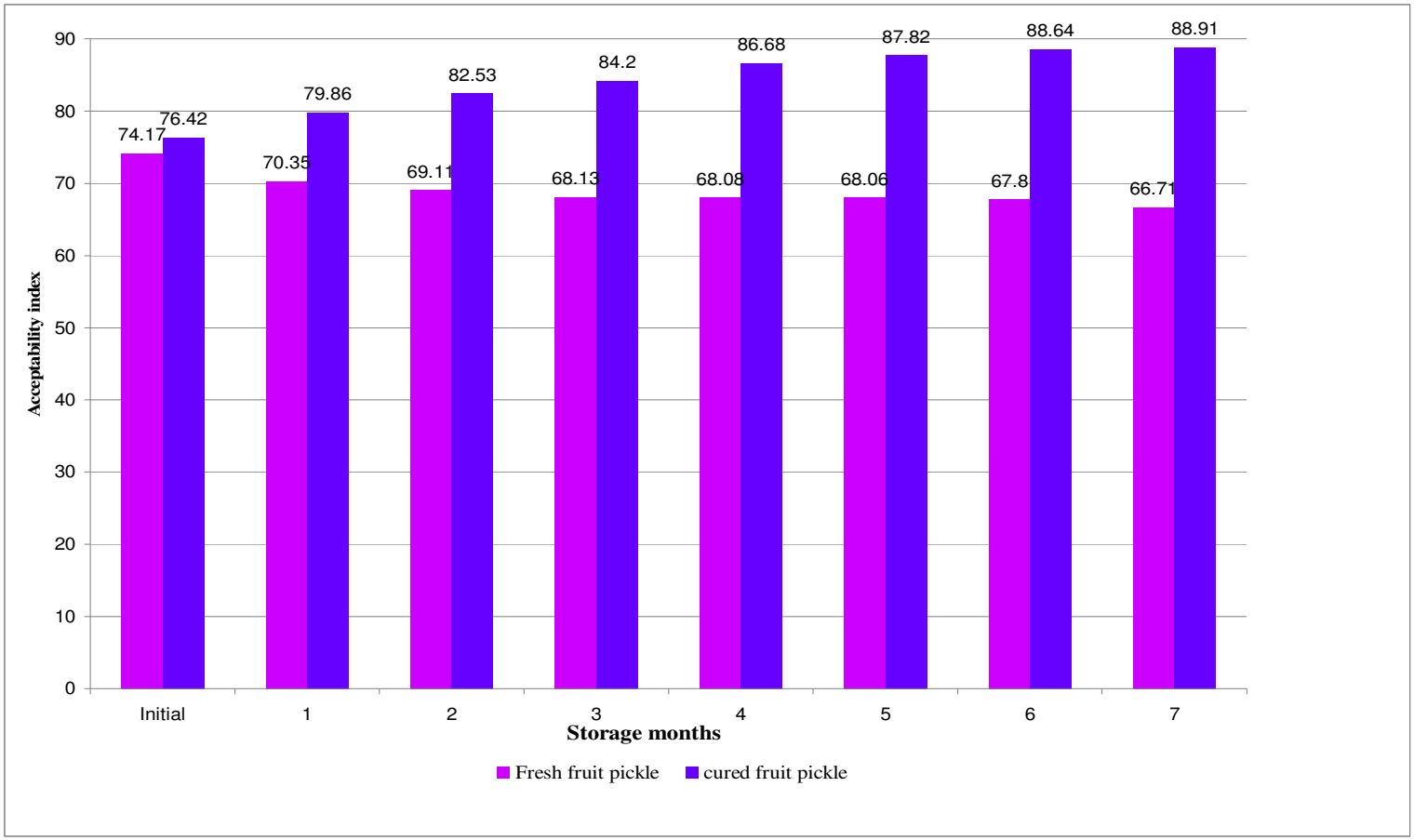


Fig 5. Effect of storage on acceptability indices of pickle prepared from fresh and cured karonda during storage

Value addition trials were conducted for preparation of glazed fruits in the form of candies, similar to the natal plum of the *Carissa* family (Table 23). It was observed that osmosis and sugar penetration into the fruit pulp was the adequate and unsuccessful .Initially moist the product was moist, Sticky, but upon dehydration though the product was dry and separate, texture was tough and unappealing. Hence the ripe fruits collected from the wild were explored for value addition in the form of jam (Table 24). The standardization trails revealed unsuccessful attempts despite the addition of green apple for good set jam. The product was dark, sticky and not acceptable as jam. Hence experiments were conducted to prepare jam of acceptable quality characters using the improved cultivated fruits of karonda.

Various trials for standardization of jam revealed encouraging results (Table 27). The jam was highly attractive, purplish red, well set with well balanced taste and flavour, even without any synthetic colours or flavours (Table 27 and Plate 5). The pH of karonda jam increased gradually during storage. Similar observations were reported by Vidya and Narain, (2011) and Sharma *et al.* (2006).It was interesting to note that the scores for all sensory attributes were higher in 3rd and 4th standardization trails, despite the fact that the poor set of jam. However, the scores did not differ significantly, indicating performance of the panel taste and flavour rather than the physical parameter of the Jam. Similar blend jam of a highly acidic Himalayan fruit sea buckthorn with apple (35:65) was indicated to be highly acceptable with an overall acceptability score of 8.34 on a nine point hedonic scale (Sharma *et. al.,* 2006). Good quality jams with other minor fruits such as smelly berry, wild loquat and marula plum could be prepared with substitution of baobab powder as a source of pectin (Ndabikunze, 2011). However minor fruits like wood apple could also be processed in to jam with good appearance, flavour, consistency, taste and overall acceptability.

Karonda jam exhibited good shelf life without any spoilage up to 7 months of storage. The sensory quality did not reveal significant changes during storage despite slight reduction in pH. Such reduction in pH due to breakdown of sugars has been reported in jams of karonda fruits (Sharma *et. al.,* 2006; Vidya and Narain 2011). Consumer acceptability evaluation of karonda pickle was highly encouraging (Table 30 and 31). On overall basis the pickles processed either by novel or traditional methods were highly acceptable. Although the value added jam scored highest among fruits based on ripe fruits, the pickles were superior to it.Majority of the subjects liked the pickle and the product was highly accepted. Among the different value added products the pickle was most accepted (Fig. 6). Thus the study indicated potential techniques for value addition to karonda which can be helpful for the extension of shelf life for better utilization.

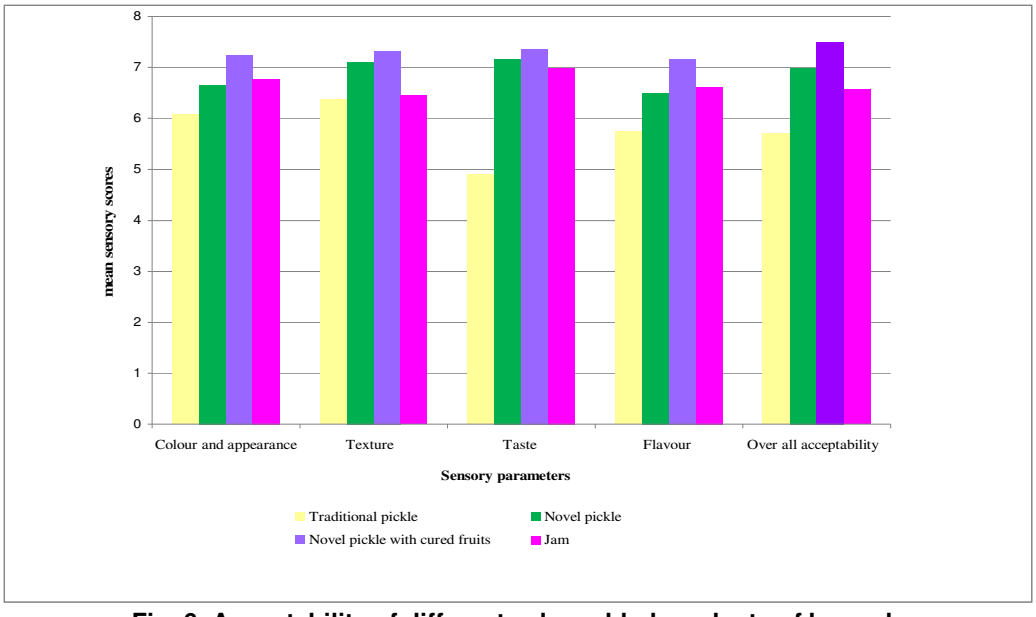


Fig. 6. Acceptability of different value added products of karonda

Plate 5. Karonda jam preparation and samples

6. SUMMARY AND CONCLUSION

India is a land of diverse agro-climatic region where plant species that yield edible fruits thrive. Among the hundreds of plant species grow abundantly even in dry arid climatic condition on marginal lands. Karonda is one of the plant which yields fruits in abundance grows gregariously in the arid region and shrub forests, all over India. Karonda fruit also commonly called as karmada, karvanda, karunda, kavali and natal plum is one such fruit which needs to be promoted for cultivation and utilization as fresh fruit or in value added food products and also for the medicinal values associated with the plant parts. The dense foliage and fibrous root system help in protecting soil health and present soil erosion. Karonda both unripe and ripe grown in the wild is collected from the shrub forests for economic benefits by the local people. The fruiting season is limited and hence a research programme was planned to study phisico-chemical characteristics, extend the shelf life and explore value addition potentials of ripe and unripe karonda (*Carissa carandas*) fruits in the department of food Science and Nutrition College of Rural Home science UAS Dharwad results of the study summariesed on the following paragraph.

Unripe fruit is sour and used for pickles, chutneys, etc. The ripe fruit is sweet but slightly acidic and contains high amounts of pectin. Therefore, besides being used for making pickle, it can be exploited on a commercial scale for the processing industries for making jelly, jam, squash, syrup and chutney, which are of great demand in the market.The present investigation was undertaken in the Department of Food Science and Nutrition, University of Agricultural Sciences, Dharwad, Karnataka to develop value added products based on unripe and ripe karonda addition to underutilised karonda fruits, to evaluate shelf life of unripe and ripe karonda fruits at ambient and refrigerated storage condition in polyethylene and paper bags, to determine ascorbic acid and selected minerals in unripe and ripe karonda and storage quality evaluation of selected value added foods.

Karonda fruits were procured from local market and improved variety of karonda fruits were procured from orchards of K H Patil, KRUSHI VIGNYANA KENDRA Hulkoti. Physico-chemical characteristics of karonda fruits were assessed employing standard procedures. Different standardization trials were conducted to develop karonda products from mature unripe green karonda were chutney, powder, fruit candy and pickles. At the same time jam, glazed karonda candy and beverages like RTS, squash, nectar were prepared from ripe karonda. The products were subjected to sensory evaluation by semi trained panel members of Food Science and Nutrition Department of University of Agricultural Sciences, Dharwad.

- Fruit morphology determines the handling properties and shelf life. The morphological characteristics of unripe and ripe wild and improved selection of karonda fruit were assessed.
- Physical parameters of the unripe and ripe wild and improved selection of karonda fruit were measured in the present investigation and the physical parameters influence the acceptability of any food by the consumers. Chemical composition of unripe and ripe wild karonda fruits estimated on fresh weight basis. Revealed higher moisture content in unripe fruits (81.83%) than the ripe fruits (80.66%). Total mineral content was 10.90 and 9.59 per cent in unripe and ripe fruits, respectively. Ascorbic acid content of unripe fruits was 17.00 mg/100 g and in ripe fruits it was 48.00 mg/100 g. The unripe and ripe karonda fruits recorded substantial levels of potassium (31.25 and 84.20 mg/100 g), zinc (1.44 and 5.83 mg /100 g), copper (1.09 and 2.05 mg/100 g), iron (0.83 and 13.90/100 g) and manganese (1.15 and 0.93 mg/100 g), respectively. Where as in improved karonda selection it was observed that, unripe fruits recorded higher moisture content (80.73%) than the ripe fruits (80.17%). Total mineral content was 9.67 and 8.00 per cent in unripe and ripe fruits, respectively. Ascorbic acid content of unripe fruits was 18.02 mg/100 g and in ripe fruits it was 51.00 mg/100 g. The fruits recorded substantial levels of potassium (26.07 and 81.26 mg/100 g), zinc (1.50 and 3.26 mg /100 g), copper (1.12 and 1.92 mg/100 g), iron (0.1 and 10.33/100g) and manganese (1.12 and 0.20 mg/100 g), respectively in unripe and ripe fruits. With regard to nutraceutical components the unripe and ripe fruits recorded 2.17 and 1.95 per cent dietary fiber with 1.20 and 0.88 per cent soluble and 1.83 and 2.15 per cent in soluble fractions, respectively.

The fruits also recorded 2.29 and 1.99 mg phytic acid and 4.97 and 2.50 mg total phenols in unripe and ripe fruits, respectively. Thus genotypic variation in the two fruits at two different stages was observed.

- The results of the studies for evaluation of ripe and unripe karonda in non ventilated and ventilated paper bags and polythene covers at ambient and refrigerated storage condition in unblanched and blanched fruits is presented in Table 5 to 9. The storability of fruits was assessed in terms of edible fruit weight retained after discarding the fruits infested, spoilt or decayed. It was observed that the storage conditions significantly influenced the storage quality of fruits. On overall basis around 80 per cent of unblanched fruit weight was retained up to 8 days of storage in paper bags and non ventilated at ambient. The blanched fruits could be stored only in paper bags and the polythene pouches were not effective in extending the shelf life. However, with respect to storage of unripe fruits in refrigerated condition, all the packaging treatments were helpful in retaining more than 90 per cent of edible fruit weight in unblanched fruits, ventilated packages were significantly superior to non ventilated packages in refrigerated storage condition.
- Several value addition trials to conduct on unripe karonda indicated that karonda could be preserved in the form of pickle over a duration of more than. Trials were conducted to develop traditional chutney with varying the proportion of added ingredients. It was observed that the product was attractive, well balanced with highest acceptability index of 71.11.
- Trials were conducted to develop karonda powder using salt. The powder containing varying levels of salt was less appealing product. The product was dull, coarse and less acidic in and flavour and exhibited less acceptable.
- Attempts were made to explore the possibility of preparation of green and ripe karonda candies using varying levels and sugar. The fruit candies were dry and separate but hard in texture. On overall basis the product was less acceptable in taste, flavour and texture.
- It is a practice to cure fruits in salt prior to pickling. Hence trials were conducted to cure karonda in salt at 15 and 20 per cent levels.
- Different standardization trials were conducted to develop traditional karonda pickle. The sensory quality evaluation. Revealed in a product increased with mean total score of 33.37 and acceptability index of 74.15, the product was less appealing as and less acceptable. Similarly, trials conducted to develop novel karonda pickle, which was acceptable well balanced product with mean sensory scored as evaluated by the semi trained sensory panel was 34.51 and acceptability index of 76.68.
- Karonda novel pickle with the cured fruits was highly acceptable in all the sensory attributes, with higher total mean score of 36.89 and acceptability index of 81.97. The product was highly acceptable.
- Different trials were tried to develop beverages such as squash, nectar and ready to serve beverages with ripe karonda, and the results were less encouraging.
- Results of the trials conducted for development of karonda jam with wild fruits revealed dark caramel brown coloured product which was set and unacceptable. The blend jam with karonda improved selection was highly acceptable in all the sensory characteristics.
- The storage did not affect colour, appearance, texture and taste of the pickles and jam which were stored for eight month at ambient storage condition. Where as the significant change was observed in taste during storage of karonda novel pickle for eight months. The scores for all the attributes decreased in karonda novel pickle, but increased in jam and novel pickle with cured fruits, during eighth month of storage at ambient.
- The consumer acceptability test carried among 160 consumers including students, house wives and working class, showed that 36 consumers liked to eat the pickle at every opportunity. The product was highly acceptable.

Future line of work:

1. Market testing of value added karonda products
2. Popularization of the value addition techniques among the people dependent on forest for income generation.

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APPENDIX-I

Standardized recipe for preparation of karonda chutney

Ingredients	Quantity (g)
Karonda	100 g
Green chillies	25 g
Jaggery	40 g
Garlic cloves	2 g
Cumin seeds	6 g
Coriander leaves	20 g
Salt	15 g
Curry leaves	2 g

Method:
The spices were ground to a fine paste in an electric mixture and the sorted fruits were added and ground to an acceptable fine texture.

APPENDIX-II

Standardized recipe for preparation of traditional karonda pickle:

Ingredients	Quantity (g)
Karonda	1000 g
Salt	200 g
Chilly powder	100 g
Turmeric powder	20 g

Method:

Firm, fresh unripe karonda fruits were washed in running water and wipe dried. The fruits were individually crushed lightly to create cracks in the fruits. All the ingredients were mixed thoroughly and bottled. The contents were rotated by shaking the bottles an alternate days. The product was ready for consumption after 15 days of curing.

APPENDIX-III

Standardized recipe for preparation of novel karonda pickle:

Ingredients		Quantity (g)
Green unripe cured karonda	-	1000 g
Green chillies	-	250 g
Mustard oil	-	300 ml
Salt	-	250 g
Fennel Seed	-	60 g
Mustard Seed dhal	-	100 g
Chilly powder	-	10 g
Kalunji seeds	-	5 g

Method:

Firm and mature fruits were selected, washed and wipe dried. The fruits were individual crushed tightly to creat cracks. Chillies were slit vertically and cut in to pieces. For the preparation of cured karonda pickle the crushed fruits were mixed with salt and allowed to cure for 30 days. After curing all other ingredients processed in as indicated above, were added and the procedure was continued.

Mustard seed dhal was warmed tightly. Fennel and kalounji seeds were heated slightly and powered coarsely. All the ingredients were mixed thoroughly and stored in a bottle. The contents were agitated on alternate days by shaking the bottles on alternate days of curing.

Cost of karonda pickle

Yeild		Price
Per 1000 g	-	54 Rs
Per 100 g	-	5 Rs

APPENDIX- IV		
Sensory Evaluation of Karonda products by 9 point hedonic scale		
Name of the Judges: **Date:**		
Parameters	Scale	Product
1. Colour and appearance	Excellent	
	Extremely good	
	Very good	
	Moderately good	
	Good	
	Fair	
	Very fair	
	Poor	
	Very poor	
2. Taste	Excellent	
	Extremely good	
	Very good	
	Moderately good	
	Good	
	Fair	
	Very fair	
	Poor	
	Very poor	
3. Texture	Excellent	
	Extremely good	
	Very good	
	Moderately good	
	Good	
	Fair	
	Very fair	
	Poor	
	Very poor	
4. Flavour	Excellent	
	Extremely good	
	Very good	
	Moderately good	
	Good	
	Fair	
	Very fair	
	Poor	
	Very poor	
5. Overall acceptability	Excellent	
	Extremely good	
	Very good	
	Moderately good	
	Good	
	Fair	
	Very fair	
	Poor	
	Very poor	

APPENDIX- V

'FACT' Scale to assess consumer acceptability of karonda pickle

Indicate your opinion by ticking any one

Date:

Scores	Scale
1	I would eat this every opportunity that I had
2	I would eat this pickle very often
3	I would frequently eat this pickle
4	I like this and eat it now and then
5	I would eat this if available but would not go out of my way
6	I don't like this but would eat this on an occasion
7	I would hardly ever eat this pickle
8	I would eat this if there were no other food choices
9	I would eat this only if forced

PHYSICO CHEMICAL CHARACTERISTICS, VALUE ADDITION AND SHELF LIFE EVALUATION OF KARONDA (*Carissa carandas*)

2012

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ABSTRACT

Karonda (*Carissa carandas*) is an evergreen plant that grows widely in tropical and subtropical climates. The plant bears abundant fruits which can be processed commercially. Physico chemical characteristics, value addition and shelf life of unripe and ripe wild and cultivated karonda were studied. Cultivated unripe and ripe fruits respectively recorded 2.79 and 3.39 g weight, 3.6 and 3.2 ml volume, 2.3 and 2.1 cm length, 1.75 and 1.5 cm girth and 2.48 and 2.71 g pulp weight. Wild fruits were highly acceptable in fresh form where as the cultivated fruits were bitter and unacceptable. Storage studies revealed that the unripe fruits packed in ventilated paper and polythene pouches could be stored up to 25 days under refrigerated condition. The fruits exhibited spoilage within one week at ambient. Ripe fruits could be stored only for 4 days in ventilated paper pouches in refrigerator. Blanching pretreatment was not beneficial. Ascorbic acid content was17-18 and 48-51 mg/100 g mg in unripe and ripe fruits, respectively. Value added experiments to develop acidulant powder, glazed fruit, chutney and pickles with unripe fruits revealed a highly acceptable pickled product with excellent shelf life of more than 8 months. Salt curing as a pretreatment enhanced the sensory quality of pickles. Trials to develop RTS beverages, nectar, squash, candy and jam with ripe fruits resulted in a highly acceptable blend jam with excellent shelf life of 7 months. Highest acceptability index was recorded for pickles prepared with cured fruits (81.97) followed by fresh fruits (76.68). The pickle processed traditionally revealed an index of 74.15. The blend jam and chutney exhibited the indices of 72.75, 71.11, respectively. Consumer acceptability evaluation of pickles revealed encouraging results.