STUDIES ON MICROWAVE DRYING AND PACKAGING OF CURRY LEAVES

By

Amitha M. Anand

Chippy Jasmine Francis

Department of Post-Harvest Technology and Agricultural Processing
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM
KERALA, INDIA

STUDIES ON MICROWAVE DRYING AND PACKAGING OF CURRY LEAVES

By

Amitha M. Anand.

Chippy Jasmine Francis.

PROJECT REPORT

Submitted in partial fulfilment of the

Requirement for the degree

Bachelor of Technology

In

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

Department of Post-Harvest Technology and Agricultural Processing
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM
KERALA, INDIA

2011

DECLARATION

We hereby declare that this project report entitled **"STUDIES ON MICROWAVE DRYING AND PACKAGING OF CURRY LEAVES"** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar title of any other University or Society.

Place: Tavanur

Date: **Amitha M. Anand**

Chippy Jasmine Francis

CERTIFICATE

Certified that this project report, entitled, **"STUDIES ON MICROWAVE DRYING AND PACKAGING OF CURRY LEAVES"** is a record of project work done jointly by Amitha M. Anand and Chippy Jasmine Francis under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, associateship or other similar title of any other University or Society.

Place: Tavanur

Date: 02/05/2012

Dr. Prince M.V.

(Project Guide)

Assoc. Professor

Department of PHT&AP

ACKNOWLEDGEMENT

It seems our vocabulary gets exhausted to express our deep sense of indebtedness and due respect to **Dr. Prince M. V,** chairman of the project and Associate Professor, Department of Post Harvest Technology and Agricultural Processing for his prolific encouragement, constructive criticisms, timely advice, infatigable concern and patience throughout the project work.

Word would not suffice to express gratitude to all teachers and staffs of PHT-AP especially **Dr. Santhi Mary Mathew**, Professor and HOD of PHT-AP.

Heartfelt thanks to **Dr. M. Sivaswami,** Dean, K.C.A.E.T, for his help and guardianship. We would like to express our sincere gratitude to **Dr. George Mathew** for his kind advice given to us at all stages of our study.

We are very grateful to **Dr. Sudheer K. P**, Associate Professor, Department of Post Harvest Technology and Agricultural Processing, K.C.A.E.T, Tavanur, for his constructive suggestions.

We are thankful to Ms. Divyasree, **and Mr. Jabsheer** for their unfailing support and readiness to spare their treasure of knowledge, time and valuable ideas at times of necessity.

Our word of thanks to all our **beloved friends** who were with us through thick and thin.

We exploit this opportunity to thank **Library Staff,** and **students** of K.C.A.E.T, who helped us in completing this work successfully.The affection and prayer of our **parents** can never be forgotten at this juncture.

Above all, we humbly acknowledge the grace and blessings of **God Almighty**, which enlightened our path throughout.

Amitha M Anand

Chippy Jasmine Francis

DEDICATED TO OUR PROFFESSION

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

SYMBOLS AND ABBREVIATIONS

&	and
ºC	degree Celsius
%	percentage
AOAC	Associates of Official Analytical Chemists
BC	Before Christ
cm	centimetre
et al.	And other people
etc.	Etcetera
Fig.	Figure
g	gram
i.e.	that is
KCAET	Kelappaji College of Agricultural Engineering and Technology
M.C	Moisture content
mg	milligram
ml	millilitre
MW	Micro Wave
no.	number
Vit	Vitamin
Viz	namely
W	Watt
wb	Wet basis

INTRODUCTION

CHAPTER 1
INTRODUCTION

Herbs have been used for time uncounted for healing the sick and infirm. Even in prehistoric days, plants were sought and used for shelter, food and medicine. Some of the ancient cave etchings have shown glyphs of plant leaves and roots being used by the caveman. There are records of the Sumerians using thyme and laurel 5,000 years ago. As far back as 2700 BC the Chinese people were known to use over 30 plants for medicinal purposes. Records of Egyptian culture, as far back as 1000 BC, tell of the common uses of many herbs and plants for food, medicine, and dyes.The ancient Greeks and Romans used herbs and other plants for cosmetics, in magical and religious ceremonies, both symbolically and realistically, and as medicine and seasonings for cooking (Leela, 2002).

Human has apparently always made use of plants, animals, and minerals in his diet and health. The plant kingdom provides the human body with the best basis for healing and for maintaining that health. The cultivation and use of herbs is as much a reality today as it has been since the dawn of history. With the advent of modern methods of food processing and chemically and biologically engineered nutrients and medicines, many natural herbal remedies have been lost and people have fallen away from their uses in food, shelter, and medicinals. This is unfortunate, as herbs and other plants still contain the vitamins, essential oils, mucilage, alkaloids and other natural ingredients that are beneficial to the body, mind, and spirit of man (Natarajan, 1974).

Asia is known as the 'Land of Spices' as it is the place of origin, production, consumption and export of most spices. 'Spice' can be defined as the dry parts of a plant, such as roots, leaves and seeds, which impart to food a certain flavour and pungent stimuli (Kenji and Takemasa, 1998). India's share in the world spice market is estimated as 46 per cent by volume and 26 per cent by value (Peter *et al.*, 2006). They are Black pepper (Piper nigrum), Cardamom(Elettaria cardamomum), Cinnamomum (Cinnamomum camphora), Chili pepper (Capsicum annuum), Clove (Syzygium aromaticum), Coriander (Coriandrum sativum), Curry leaves (Murraya koenigii), Cumin (Cuminum cyminum), Garlic (Allium sativum), Ginger (Zingiber officinale), Turmeric (Curcuma longa), Vanilla (Vanilla planifolium), Nutmeg and Mace (Myristica fragrans). India produces about 64 varieties of spices and is the world's largest producer and exporter, accounting for about 20 percent of world consumption (Menon, 1998). Also India is the second largest producer of vegetables in the world and contributes about 13 per cent of the world's production (Fathima *et al.*, 2001). Leafy vegetables are relatively inexpensive, easy to cook and rich in several nutrients .In India, different varieties of green leafy vegetables are available during winter season. The leafy vegetables are highly perishable in nature and therefore have very short shelf life (Uadal *et al*., 2010).

Leaves are especially good sources of vitamin A, vitamin C, and folic acid vitamins most likely to be lacking in the diet. Leafy vegetables are rich in iron and calcium, needed for strong blood and bones. They also supply trace minerals that are essential to good health, but that are often not adequately supplied by processed foods. Leaves are a good source of dozens of antioxidants which can reduce our risk of cancer, heart attacks, and several other diseases, by protecting our cells form premature oxidation. Green leaves have plenty of fibre, the indigestible parts of plant foods that are essential to the digestive tract. Fibre in the diet also reduces cholesterol and the risk of heart attacks and strokes.

The curry leaves (*Murraya koenigii*) a green leafy vegetable, is also been used as spice after its drying. They impart health benefit by providing the much needed dietary essential minerals and vitamins to the human diet .The demand for fresh and dried curry leaves has considerably increased over the last two decades (Sakhale *et al*., 2005).

Fresh green curry leaves contains about 75 -90% water. They wilt and become inedible in a day or two without refrigeration. However, the post harvest and nutritional losses occur during handling, transportation, processing and storage, which have gone up to 40 per cent annually. When they are dried to less than 10 % water they remain good to eat for several months. Drying makes curry leaves available year round. The challenge of drying is to reduce the moisture content to a certain level where microbiological growth will not occur while maintaining high nutrient value. A number of drying techniques have been developed over the years. Except for freeze drying, applying heat during drying through conduction, convection and radiation are the basic techniques used to force water to vaporise, while forced air is applied to encourage the removal of the vapour.

The drying method should be constant into the particular characteristics of the products and socio-economic considerations. Energy consumption is a critical issue in the selection of a drying process and with the increase in fuel prices it becomes an important factor at the industry level. To reduce the use of fossil fuel, electrical energy is an alternate source of energy for drying applications especially where electricity is generated by a renewable energy source such as hydro or wind power.

Children and the elderly, in particular, often find the texture to be stringy and difficult to chew. Drying the greens and grinding them to a powder eliminates this problem. Also, because the leaves are finely ground, digestive enzymes can work on far more leaf surface area resulting in better absorption of nutrients. Fresh greens are difficult to use into most dishes and as a result their role in the diet is often limited to minor addition in food preparation. Dried green leaf powder can be incorporated into a much wider range of foods (David Kennedy , 1998).

Drying the curry leaves is one of the feasible methods of its preservation. Research needs to be carried out to explore the possibility of employing drying techniques for easy, economic and efficient processing to minimize the nutrient and other flavour losses and to make them available for consumption in the off-season. Packaging is an integral element in the marketing of fresh and processed products. It provides an essential link between the producer and the consumer (Chaudary *et al*., 2006). Also curry leaf is widely used around the world to flavour curries, and other deliciousness'. The availability of leaf during summer season is low leading to sharp increase in prices of the fresh leaves. The post- harvest processing of curry leaf thus can help in fetching better prices to the farmers.

Based on the above facts, an investigation was undertaken to study the effect of microwave drying of curry leaves and also to study its packaging with the folloeing objectives,

1) To study the microwave drying of curryleaves.

2) To compare the qualitative and organoleptic properties of microwave dried curry leaves with that of conventional drying methods.

3) To conduct studies on packaging of dried curry leaves..

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

This chapter outlines a brief review on the composition of curry leaves, its characteristics, qualitative analysis, drying methods and packaging of curry leaves.

2.1 Curry Leaves

2.1. 1 Origin

Curry leaves (*Murraya koenigii*) are widely used for its culinary and medicinal properties. The curry leaf is native to India and is found nearly everywhere in the Indian subcontinent. *Murraya koenigii* is commonly found in the outer Himalayas, from the Ravi eastwards, ascending to 5,000 feet, in Assam, Chittagong, Upper and Lower Burma. It is also found in evergreen and deciduous forests of peninsular India. India is the largest producer and consumer of curry leaf (Abraham *et al*., 1951).

The Southern state of Tamil Nadu is one of the major curry leaf producing area. The trade in the spice is limited to few Asian countries. The leaves are used in fresh or dried form for flavouring curries, vegetable, fish and meat dishes, soups pickles, butter milk preparations and chutneys. It is also found in Srilanka and many parts of south East Asia including Indonesia, Burma, Thailand, etc. Curry leaf is considered an important ingredient in South Indian and Sri lankan cuisine. Its fresh and pleasant flavour enhances the taste of the dish in which they are incorporated (Chakravorthy, 1964).

Jain(1965) reported that curry leaves are mentioned in ancient Indian text. The Tamil literature specifically mentions about their use and importance. The use of curry in Indian food has also been mentioned in Ancient Kannada text. In south India curry leaves are known by the name of kari-pattha'. In modern period Britishers used curry leaf powder 'to impart an Indian taste to the food.

2.1.2 Structure and composition of curry leaves.

Curry leaf is a small spreading shrub, about 2.5 metres high; the main stem, dark green to brownish, with numerous dots on it; its bark can be peeled off longitudinally, exposing the white wood underneath; the girth of the main stem is 16 cm. Leaves are exstipulate, bipinnately compound, 30 cm long, each bearing 24 leaflets, having reticulate venation; leaflets, lanceolate, 4.9 cm long, 1.8 cm broad, having 0.5-cm-long petiole. Almost every part of this plant has a strong characteristic odour(Jalaluddin, 1990).

Chowdary *et al*., (1964) stated that the leaves are rich source of carbohydrates, proteins, amino acids and alkaloids, and are rich in minerals, vitamins A and B. They also a rich source of calcium, but due to the presence of oxalic acid in high concentration (total oxalates, 1.35%; soluble oxalates, 1.15%), its nutritional availability is affected.

Table 2.1: Constituents Of Curry Leaves (Source: Chowdary *et al*., (1964))

Constituents	**Proximate composition**
Moisture (%)	63.4
Protein (%)	5.9
Fat (%)	0.9
Fibre (%)	6.3
Carbohydrate (%)	15.6
Ash (%)	3.9
Calcium (mg/100g)	825
Iron (mg/100g)	0.90
Ascorbic acid (mg/100g)	3.9

The leaves also contain a crystalline glucocide, koenigiin and a resin. Macleod and Pieris(1985) analysed the concentrated essence of M**.** *koenigii* leaf and reported that the most important constituent of M. *koenigii* are β-caryophyllene, β-gurjunene, β-elemene, β-phellendrene
and β-thujene. The leaves contain the following free amino acids: asparagine, glycine, serine, aspartic acid, glutamic acid, theonine, alanine, proline, tyrosine, tryptophan, amino butyric acid, phenylalanine, leucine, isoleucine, and traces of ornithine, lysine, arginine and histidine.

2.1.3 Uses

The leaves, the bark and the roots of *Murraya koenigii* can be used as a tonic and a stomachic. The bark and the roots are used as a stimulant by the physicians. They are also used externally to cure eruptions and the bites of poisonous animals. The green leaves are stated to be eaten raw for curing dysentery, and the infusion of the washed leaves stops vomiting (Watt, 1891; Kirtikar and Basu, 1935; Dastur, 1962).

A strong odiferous oil occurs in the leaves and the seeds of *Murraya koenigii.* Gautam and Purobit (1974) reported that this essential oil exhibited a strong antibacterial and antifungal activity. An alkaloid, murrayacinine, is also found in this plant (Chakrabarty et al., 1974).

M. koenigii leaves are used in traditional medicine, for example ayurvedic and unani medicine. The green leaves are used to treat piles, inflammation, itching, fresh cuts, dysentery, vomiting, burses and dropsy. The green leaves are also eaten raw as a cure for diarrhoea and dysentery; bruised and applied externally to cure eruptions; given as a decoction with bitters as a febrifuge; and in snake bite. Its leaves have a potential role in the treatment of diabetes. The undiluted essential oil exhibited strong antibacterial and antifungal activity when tested with microorganisms . Even the crude leaf extracts of *M.koenigii* leaf plant are reported to possess antibacterial activity . An essential oil, a glucoside and koeinigin are reported from the species. The essential oil is used in soaps and perfume industry (Chakrabarty et al., 1974).

The leaves of *Murraya koenigii* are also used as a herb in Ayurvedic medicine. Their properties include much value as an anti-diabetic (Arunselvan *et al*., 2006; Yadav *et al*., 2002; Vinuthan *et al*., 2004; and Achyut *et al*., 2005), antioxidant (Arunselvan *et al*.,2007; Vinuthan *et al*., 2004; Singh et *al*., 1978; Goutam *et al*., 1974; Deshmukh *et al*., 1986; Baliga *et al*., 2003), antimicrobial (Abhishek Mathur *et al*., 2010);, anti-inflammatory (Muthumani *et a*l.,2009), hepatoprotective (Pande *et al*., 2009), anti- hypercholesterolemic (Iyer *et al*., 1990 and Khan *et al*.,1996), as well as efficient against colon carcinogenesis (Iyer *et al*., 1990) etc. Curry leaves are also known to keep the hair long and healthy.

Patel and Rajorhia(1976) reported that ghee samples treated with 1% curry leaves during clarification showed higher resistance to oxidation and higher sensory scores than those treated with a mixture of BHT (butylated hydroxy toluene) and BHA (butylated hydroxy anisole), due to the presence of naturally-occurring antioxidants. The curry leaves at 1% concentration could be used instead of BHT and BHA for extending the shelf-life of ghee (Peter et al., 2000). The branches of *Murraya koenigii* are very popular for cleaning the teeth as datum and are said to strengthen the gums and the teeth. This plant is quite ornamental due to its compound leaves. It can, therefore, be used as a hedge and as an ornamental shrub.

Plate 2.1 *M. koenigii* tree plant

Plate 2.2 *M. koenigii* leaves

2.1.4 Essential oil.

An essential oil is a liquid that is generally steam or hydro-distilled from flowers, leaves, bark and roots of plants and trees and are the compounds responsible for the aroma and flavour associated with herbs, spices, and perfumes. The formation and accumulation of essential oils in plants have been reviewed by Croteau (1986), Guenther (1972) and Runeckles and Mabry (1973).

Jerry(1970) reported that the essential oils from aromatic plants are for the most part volatile and thus, lend themselves to several methods of extraction such as hydro distillation, water and steam distillation, direct steam distillation, and solvent extraction. The specific extraction method employed is dependent upon the plant material to be distilled and the desired end-product. The essential oils which impart the distinctive aroma are complex mixtures of organic constituents,
some of which being less stable, may undergo chemical alterations when subjected to high temperatures. In this case, organic solvent extraction is required to ensure no decomposition or changes have occurred which would alter the aroma and fragrance of the end-product.Generally, essential oils are clear, however there are some exceptions. The essential oil of *M. koenigii* leaves are dark yellow in colour.

Jasim(1972) studied the chemical composition of the leaf oils of Murraya koenigii (L.) Spreng and M. paniculata (L.). Jack from Bangladesh employing gas chromatography mass spectroscopy (GC-MS). M. koenigii oil contained 39 compounds of which the major is 3-carene (54.2%) followed by caryophyllene (9.5%). Oil of M. paniculata contained 58 compounds of which the major are caryophyllene oxide (16.6%), β-caryophyllene (11.8%), spathulenol (10.2%), β-elemene (8.9%), germacrene D (6.9%) and cyclooctene, 4 methylene-6-(1-propenylidene) (6.4%). The composition of both oil varied qualitatively and quantitatively.

Iskander(1985) reported that the composition of the essential oil of M. koenigii may differ at different places. Earlier investigations on Indian curry leaf oil, hydrodistilled from fresh leaves, led to the identification of α-pinene, β-pinene, β-caryophyllene, isosafrole, lauric and palmitic acids . Later, Sri Lankan oil was reported to contain monoterpenes (15.9%) and sesquiterpenes (80.2%) with β-phellandrene, β-caryophyllene, β-gurjunene, β-elemene, and α-selinene as the main constituents. However, Chinese curry leaf oil was reported to contain α- and β-pinenes, β-caryophyllene and γ-elemene as main constituents, whereas curry leaf oil from Malaysia was shown to be rich in monoterpenes and oxygenated monoterpenes (85%) with α-pinene, limonene, β-phellandrene, terpinen-4-ol and β-caryophyllene as the main contents .

Chowdhury(1985) reported that leaves on hydrodistillation gave 0.5% essential oil on fresh weight basis, having dark yellow colour, spicy odour and pungent clove-like taste.

2.1.4.1 Essential oil extraction methods.

Various methods have being employed these days for extracting essential oils from different spices and herbs. Hydro distillation and solvent extraction are the common extraction methods being used to extract *M. Koenigii* leaves.

2.1.4.1.1 Hydro distillation.

Hydro distillation is one of the oldest methods of extraction used. The spice is fully immersed in hot water. The result is a soup, which carries aromatic molecules of the plant. The method is not much in use these days, because of the risk of overheating the plant and subsequent loss of the oil. The method is best suitable for spice in dry and powdered form of roots and barks (Chakrabarty *et al*., 1979).

2.1.4.1.2 Solvent extraction.

Extraction may not be practical for many of the herbs and spice crops by distillation process. Solvent extraction is the safest method for extracting high quality oil. In this process, the spices or herbs plants are immersed in the solvent and the 'separation' is performed chemically. These include pigments, volatile molecules and non-aromatic waxes. The herbs and spices are then subjected to low pressure distillation and the volatile oil is then separately collected. It should be noted that, even with the most advanced techniques, absolutes extracted in this manner do contain traces of solvent (Iskandar, 1982).

2.2 Drying.

Drying is one of the oldest methods of food preservation. Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. Water content of properly dried food varies from 5 to 25 percent depending on the food. According to Kendall, successful drying depends on: enough heat to draw out moisture, without cooking the food; dry air to absorb the released moisture; and adequate air circulation to carry off the moisture.

Sahay and Singh (1994) reported that when drying foods, the key is to remove moisture as quickly as possible at a temperature that does not seriously affect the *flavour*, texture and color of the food. If the temperature is too low in the beginning, micro organisms may survive and even grow before the food is adequately dried. If the temperature is too high and the humidity too low, the food may harden on the surface. This makes it more difficult for moisture to escape and the food does not dry properly.

Sriyana Abdulla *et al*., (1983) conducted studies on the drying characteristics and relationship between drying temperature and marker compounds constituent of *misai kucing* (Orthosiphon staminiues Benth.) leaves were investigated. The leaves of misai kucing herbal plant were dried by oven method at different temperatures: 40^0C, 55^0C and 70^0C. Drying at higher temperature shortened the drying time and increased the drying rate. Initial moisture content of the leaves was 77.00% (w.b). The drying process was done until the equilibrium moisture content was achieved. The total antioxidant activity of the dried leaves extract increased with the oven temperatures.

The total phenol content (TPC) in the extract was not significantly affected by the oven temperatures ($P>0.05$). The high performance liquid chromatography (HPLC) analysis for main marker compounds concentration which sinensetin (SEN) and rosmarinic acid (RA) were increased and decreased with the temperatures, respectively.

Drying curry leaves in oven at 50°C was reported to be completed in 5.02 hours while drying in sun (35°C±2) and shade (25°C ± 2) require 3.16 and 7.20 days, respectively (Madalgiri et al.,1996). Among the three drying methods, oven drying was found to be superior with emerald green coloured curry leaf powder.

A study was conducted by Singh and co-workers, (1997) to dehydrate the selected green leafy vegetables (fenugreek leaves, mustard leaves, bathu and spinach) by mechanical and sun drying methods. The dehydration kinetics revealed that the moisture content decreased very rapidly during the first hour of drying with sun drying requiring about eight hours and mechanical drying about four hours to reach the desired moisture level of 9-11 per cent.

Lakshmi and Vimala (2000) reported that, sun drying (35-40°C) of amaranth, curry leaves, gogu and mint required 14, 10, 24 and 21 hours, respectively, while in cabinet drier (60-70°C) the same leafy vegetables could be dried in 2.5, 1, 3 and 2.5 hours respectively.

According to Pande and associates (2000), methi required 4.5, 3.5, 3.0 and 2.5 hours for drying in a forced circulation drier at 40, 45, 50 and 60°C respectively whereas coriander leaves could be dried in 3.5, 3.0 and 2.5 hours at respective temperatures.

Unde *et al*. (2000) reported that the time required for sun drying of cabbage, coriander leaves and palak was 4.5, 3.0 and 3.0 hours respectively, while in solar cabinet drier the vegetables could be dried in 14.0, 8.0 and 8.0 hours respectively. The vegetables blanched in osmotic solution of salt (5%) and KMS (0.1%) maintained at room temperature (cold) or at 60°C (hot) produced dehydrated product with 7.5:1, 5.2:1 and 7.4:1 dehydration ratio respectively after drying in electric tray drier. The osmodehydration treatment caused a weight loss of 12.8 and 18.8 per cent in cold and hot brining.

Birar *et al.* (2001) revealed that the total time of five, three and six hours was required for cold and hot brined and unbrined methi to be dried in a cabinet drier at 60°C.

Bhosale and Arya (2004) studied the effect of different modes of drying on moisture content and drying time of selected leafy vegetables. The results showed that the cabinet drying was a faster drying mode requiring less time for drying the vegetables than sun and shade drying. Shade drying required maximum time for drying the samples. The time required for drying cabbage, fenugreek and spinach was 5.30, 2.30 and 3.30 hours, respectively in cabinet drier, 8.30, 5.15 and 6.00 hours, respectively under sun, and 32, 27 and 29 hours, respectively under shade. The moisture content of cabinet tray dried cabbage, fenugreek and spinach (8.05, 7.50 and 8.33% respectively) was significantly less than sun (9.13, 9.16 and 9.53% respectively) and shade dried samples (9.60, 9.25 and 10.26% respectively).

Singh *et al*. (2006) studied the effect of drying conditions on quality of dehydrated leafy vegetables. Drumstick leaves took seven hours for drying while others took six hours under the same drying conditions. Among the driers, cabinet dryer was superior for dehydration of leafy vegetables as it reduced maximum moisture (2.5%) in both curry leave sand methi. The moisture content was higher in drumstick leaves (5.5%) and amaranth (5.2%) after dehydration.

2.3 Impact Of Drying On Nutritive Value.

Drying of GLVs not only preserves them for prolonged period but also can act as a rich source of micronutrients for use in sparse season. The process of dehydration might affect the nutritional and other compositions. While studying the nutritive value of dehydrated green leafy vegetable powders (amaranth, curry leaves, gogu and mint) Lakshmi and Vimala (2000) reported that in spite of considerable losses in vitamins, green leafy vegetable powders retained good amounts of protein, fiber and minerals (Ca, Mg, and Fe) and fair amounts of vitamin C and ß-carotene.

The treatments given to green leafy vegetables(GLV) included, blanching in solutions of sodium chloride (2.0%), magnesium oxide (0.1%), sodium meta bi sulphate (0.5%), potassium meta bi sulphate (0.5%) and sodium bicarbonate (0.1 and 0.2%). Among all the treatments given to amaranth, highest ascorbic acid retention was found in samples blanched in 0.1 per cent magnesium oxide (36%) while, the lowest value was recorded in samples blanched in 2.0 per cent sodium chloride (8%). In curry leaf the retention of ascorbic acid was more or less equal in samples blanched using 2.0 per cent sodium chloride (41%) and those blanched in 0.1 per cent magnesium oxide (43%). In gogu, 2.0 per cent sodium chloride and 0.5 per cent potassium metabisulphate treated samples showed ascorbic acid retention of 21 and 19 per cent respectively when compared with plain water blanched samples (47%).

Gupta *et al*., (2003) studied the influence of dehydration on the nutrient composition of green leafy vegetables (GLV). Shepu, bathua, kilkeerae, curry leaves and keerae were steam blanched for five minutes and dried in an oven at 50°C for 10-12 hours. The ascorbic acid, ß-carotene and available iron (in the fresh vegetable) ranged from 29-78, 2.70-8.84 and 0.64-2.4 mg/100g respectively, of which 1-9, 20-79 and 16-27 per cent respectively were retained after dehydration. Dehydration did not alter the total iron content of the greens.

Lalitha and Sathya (2003) dehydrated curry leaves, drumstick leaves and coriander leaves to develop instant mixes by incorporating it in powder form. Fresh coriander leaves had the highest moisture (77.9%) and ß-carotene (130.8 µg) contents. The yield of sun dried powder was less than that of oven dried ones. Oven dried samples of all three leaves retained maximum ß-carotene content and among them the retention was higher in drumstick leaves (82.3 µg). The incorporation of GLV powders showed an increase of more than 93 per cent in ß-carotene content which was also organoleptically acceptable.

Kowsalya and Vidhya (2004) assessed the nutritive value of dehydrated GLVs such as aria keerai, mulla keerai, paruppu keerai and drumstick leaves. Iron content of dehydrated vegetables ranged from 25.5 mg in sun dried drumstick leaves to 269 mg in arai keerai. ß-carotene after dehydration ranged from 41.74 mg in sun dried drumstick leaves to 97.85 mg in cabinet dried paruppu keerai. Cabinet drying indicated better nutrient retention than sun and shade drying.

2.4 Process, Pre Treatments And Methods Of Drying

Bajaj and co-workers (1993) studied the effect of blanching treatments on the quality of dehydrated fenugreek leaves. Different blanching treatments consisted of hot water and solutions containing sodium chloride (2%), magnesium oxide (0.1%), sodium meta bisulphate (0.5%), potassium meta bisulphite(KMS) (0.5%), sodium bicarbonate (0.1% and 0.2%) either singly or in combination. Ascorbic acid retention was maximum (39.2%) in samples treated with KMS solution, while chlorophyll loss was minimum (7.3%) in plain water blanched samples. However, MgO solution resulted in better retention of chlorophyll on storage for six months. The rehydration ratio of the dried fenugreek leaves with the different blanching treatments (blanching in water, blanching in solutions either singly or in combination) ranged from 5.9 to 7.2, the highest being with sulphitation treatment.

Dehydration characteristics of spinach, mustard, fenugreek and bathu leaves were studied by Singh *et al*., (1997). The study revealed that maximum chlorophyll retention was observed in blanched bathu (65-70%) and least (50%) in spinach. It was indicated that blanching helped in retention of chlorophyll. The colour of sun dried samples was severely deteriorated hence it was not analysed. Among all tray dried and sun dried leafy vegetables, spinach exhibited lowest rehydration ratio. While, fenugreek recorded maximum rehydration ratio when sun dried, bathu registered highest when dried in trays under shade.

Gupta *et al*., (1999) carried out a study on improvement in rehydration and shelf life stability of hot air dried and sun dried cabbage by pre drying treatment. Both treated (soaking in solutions containing 3% salt, 6% sugar and a combination of both at 0-4 °C for 12- 16 hours) and untreated (only blanched) cabbage was soaked at room temperature in 0.2 percent KMS solution for 10 minutes and dried in hot air oven, solar cabinet drier and under direct sun. The results showed that incorporation of sugar increased the drying time of cabbage by one hour in hot air oven (8 hours), four hours in direct sun (13 hours) and threehours in solar cabinet drier (12 hours) apparently due to the humectant effect of sugar.

Lakshmi and Vimala (2000) tried various blanching treatments (blanching in solution of 2% sodium chloride, 0.1% magnesium oxide, 0.5% sodium meta bisulphate, 0.5% potassium meta bisulphate, 0.1 and 0.2% sodium bicarbonate) in preparing leafy vegetable powders (amaranth, curry leaves, gogu and mint). Amaranth and mint leaves blanched in hot water containing magnesium oxide (0.1%) registered higher retention of chlorophyll (39 and30% respectively) compared to other methods of blanching. Curry leaves retained maximum chlorophyll (51%) when blanched with sodium chloride (2%). Gogu treated with both sodium chloride (2%) and sodium meta bisulphite (5%) showed greater retention of chlorophyll (38%). The rehydration ratio of amaranth, curry leaves, gogu, and mint was found to be higher in sun dried samples (7.38, 4.06, 5.86 and 6.09 respectively) and lower in cabinet dried samples (6.81, 3.74, 5.46 and 6.46 respectively).

The study of Unde *et al*., (2000) revealed that cabbage, coriander and palak, blanched in osmotic solution (5% salt and 0.1% KMS) produced rehydration ratio of 5.2:1, 4.0:1 and 4.5:1 respectively after drying in electric tray drier.

Blanching of amaranth in hot water (95 ± 3°C) for one minute followed by cooling in running tap water and dipping in 0.5 per cent solution of potassium meta bisulphite for one minute prior to drying in cabinet drier showed higher retention of chlorophyll, ß-carotene and lowered non-enzymatic browning (Negi and Roy, 2001).

The effect of blanching prior to dehydration in cross air flow drier was studied in seven leafy vegetables viz., dhantu, khirkhire, honagone, chakota, palak, kachi and fenugreek (Premavalli *et al*., 2001). The GLVs were blanched in boiling water containing sodium bicarbonate (0.1%) and MgO (0.1%) and sodium metabisulphate (0.2%) for two minutes prior to dehydration. The highest retention of chlorophyll was found in fenugreek (95%), followed by palak (89.3%). Khirkhire (88%) and chakota (87.3%). Least retention was observed in honagone (51.35%) followed by kachi (59.80%). Retention of total carotenoids on dehydration was highest in chakota (94%) followed by palak (82.7%) and kachi (79.3%). Dhantu (71.4%) and fenugreek (71.2%) showed similar retention of total carotenoids. Least retention was observed in honagone (36.1%) followed by khirkhire (66%).

Kowsalya and Vidhya (2004) assessed total carotenoids present in dehydrated GLVs which ranged from 91.58 mg (drumstick leaves) to 189.56 mg (arai keerai). In comparison with shade and sun drying, all cabinet dried vegetables showed relatively less rehydration ratio. The rehydration time was 30 minutes for all the greens and rehydration was better in boiling water.

Singh *et al*., (2006) carried out a study on effect of drying conditions on the quality of dehydrated leafy vegetables (amaranth, curry leaves, drumstick leaves, methi and palak). The data revealed that the rehydration ratio was higher in the product dehydrated in cabinet drier and it was comparatively low in the products dried at low temperature and in solar drier. Among all the driers the cabinet drier was found to retain higher proportion of chemical constituents such as ß-carotene (2685 to 4850 µg / 100 g) and chlorophyll (70.0 to 130.3 µg /100 g) than solar and low temperature drier. The loss of ascorbic acid was higher in the solar dried vegetables as compared to cabinet and low temperature dried vegetables. Maximum loss of ascorbic acid was observed in palak and amaranth and least in curry leaves followed by drumstick leaves.

2.5 Organoleptic Evaluation Of Dried Leaves.

The dehydration processes not only affects the colour and other pigments but also the sensory attributes like colour, appearance, texture, aroma and overall quality to a varying degree. These variations depend not only on the type of vegetable but also on the method of processing.

Bajaj *et al*., (1993) evaluated culinary quality of blanched and dehydrated fenugreek leaves. Colour, texture, aroma and overall quality of blanched leaves received significantly higher scores than un blanched. Among the blanching treatments, plain water, magnesium oxide (0.1%) and sodium bicarbonate (0.1%) were found to be better blanching solutions in terms of quality. Blanching as a pre-treatment prior to drying in sun and shade resulted in organoleptically acceptable product from fenugreek. On comparison with untreated fenugreek, blanched fenugreek leaves obtained better scores for all sensory parameters even up to three months of storage. It was also concluded that drying of vegetables under sun is effective method (Sukanya *et al*., 1995).

Singh *et al*., (1997) studied sensory evaluation of dehydrated leafy vegetables viz., spinach, mustard leaves, fenugreek, bathu by using four point scale. The sensory data revealed that a desirable colour was obtained in case of tray drying while the colour of sun dried products was un acceptable . However, the flavour of all vegetables was found to be better in case of sun dried products as compared to tray dried except fenugreek wherein both methods of drying were on par . There was no difference in scores obtained for texture by fenugreek and mustard leaves in both the methods of drying . While, bathu and spinach dried under sun received scores of three and four respectively, those dried under cabinet received the scores of four and three respectively. The overall acceptability of the products was excellent . Among tray dried samples fenugreek performed the best followed by spinach, bathu and mustard leaves, while the scores were lowest for sun dried fenugreek followed by bathu, mustard leaves and spinach.

The treated samples with sugar (6%) alone and in combination with salt (3%) and sugar (6%) brought about considerable improvement in colour (natural), appearance (nearly full and full), texture (tender and very tender with crisp) and overall acceptability (very good and excellent respectively) than in untreated cabbage (Gupta et al., 1999).

Lakshmi and Vimala (2000) evaluated the powders of amaranthus, curry leaf, gogu, mint and their blended forms after rehydration, for colour, texture, taste and overall acceptability which ranged from average to excellent. It was possible to retain the bright green, whereas the original flavour of leaves could not be retained completely.

The sensory evaluation of dehydrated methi leaves after rehydration was carried out by Birar et al. (2001). Results revealed that the samples pre treated with 15 per cent hot brine (60°C) received higher scores for colour and appearance, flavour, texture, taste and overall acceptability.

Singh *et al*., (2006) carried out organoleptic evaluation (5 point hedonic scale) of selected dehydrated leafy vegetables on five point hedonic scale with one denoting excellent. The study showed that the sensory score for all the GLVs viz., amaranth, curry leaves, drumstick leaves, methi, palak was excellent under cabinet drier. Amaranth was excellent in colour (1.1), flavour (1.3) and good in texture (2.2). Curry leaves and palak scored alike as excellent in flavour (1.1 and 1.5) and texture (1.2 and 1.1) while good in colour (2.4 and 2.2). The overall high score was obtained by cabinet dried vegetables while solar dried vegetables were poor in sensory characteristics.

According to DiPersio (2000) water blanching is recommended over steam blanching or blanching in a microwave because water blanching achieves a more even heat penetration than the other two methods. Plain water or water with added citric acid may be used. Citric acid acts as an anti-darkening and anti-microbial agent. Prepare the citric acid water by stirring 1/4 teaspoon (1 gram) of citric acid into one quart (approximately one litre) of water.

2.6 Microwave Drying

In microwave drying, when the material is subjected to microwave energy, heat is generated within the product through molecular excitation. The critical next step is to immediately remove the water vapour. A simple technique for removing water is to pass air over the surface of the material hence combining processes to form what is called "microwave convective drying". In many cases when microwave drying is mentioned, it implies that it is microwave convective drying.

The air temperature passing through the product can be varied to shorten the drying time. The selected air temperature is dependent on the product's characteristics. In order to control the product's temperature, either power density (watts/grams of material) or duty cycle (time of power on/off) must be controlled. The drying of banana slices with microwave drying demonstrated that good quality dried products can be achieved by varying power density and duty cycle time.

Development of temperature profiles in the MW heating period has been studied for various geometries. During MW drying processes, the heating period is relatively short and moisture loss is small (Bouraoui *et al*., 1994). Much of the moisture loss takes place during the second period of MW drying, and moisture distribution in spherical foods is determined at this period through experimental measurements of moisture profiles and computer simulation. Dielectric heating with MW energy has found industrial applications in drying food products such as fruits and vegetables. There is a renewed interest in exploring the unique characteristics of MW heating for drying heat-sensitive materials (Funebo and Ohlsson, 1998).

Vega-Mercado *et al*., (2001) considered the use of MW as the fourth generation drying technology. In general, a complete MW drying process consists of three drying periods. (1) A heating-up period in which MW energy is converted into thermal energy within the moist materials, and the temperature of the product increases with time. Once the moisture vapor pressure in food is above that of the environment, the material starts to lose moisture, but at relatively smaller rates. (2) Rapid drying period, during which a stable temperature profile is established, and thermal energy converted from the MW energy is used for the vaporization of the moisture. In porous food structures, rates of moisture vaporization at different locations in foods depend, to a large extent, upon the local rates of thermal energy conversion from MW. (3) Reduced drying rate period, during which the local moisture is reduced to a point when the energy needed for moisture vaporization is less than thermal energy converted from MW. Local temperature then may rise above the boiling temperature of water. Even though loss factors of the food materials decrease with moisture reduction and the conversion of MW energy into heat is reduced at lower moisture content, product temperature may still continue to rise, resulting in overheating or charring.

Tein *et al*., (1998) compared dried carrot slices using vacuum/microwave drying with air and freeze drying on the basis of rehydration potential, colour, density, nutritional value and textural properties. Microwave vacuum dried carrot slices had higher rehydration potential, higher β-carotene and vitamin C content, lower density and softer texture than those prepared by air drying. Although freeze drying of carrot slices yielded a product with improved rehydration potential, appearance and nutrient retention, the microwave vacuum drying of carrot slices was rated as equal to that of freeze drying. Similar results were reported by Regier *et al*., (1998) where microwave vacuum dried carrots had the highest carotenoid retention compared with freeze drying and convection drying.

To control the product temperature during the microwave vacuum drying process it is possible to adjust microwave power or select intermittent mode. Wei *et al*., (1999) found that at the vacuum level of 5.1 kPa absolute pressure, 1.5 W/g power density provides more suitable drying conditions in continuous mode for drying cube carrots. In the intermittent mode, 90 s "on" and 30 s "off" mode under 2.0 W/g at an absolute pressure of 5.1 kPa provided the proper drying conditions. The results also show that the combination of continuous and intermittent mode is an alternative power management of microwave which improves energy utilisation and accelerates the drying rate.

A comparative study was conducted by Cui *et al*., (2000) for garlic drying. Freeze drying, microwave vacuum drying and hot air drying effects on loss of pyruvate were compared. Best dried garlic quality was obtained with freeze drying and microwave vacuum drying as a close second. On the other hand there was a great loss in garlic pungency with the hot air dried samples. Sharma and Prasad (2000) came to a similar conclusion when comparing hot air drying with microwave convective drying of garlic. They obtained a drying time reduction of 80% with superior quality dried garlic when combining microwaves at 0.4 W/g to hot air at 60–70°C.

In a comparative study conducted by Sunjka *et al*., (2002) microwave vacuum drying of cranberries exhibited enhanced characteristics when compared with microwave convective drying. Drying performance results (defined as mass of evaporated water per unit of supplied energy) showed that microwave vacuum drying is more energy-efficient than microwave convective drying.

Beaudry *et al*., (2000) studied the effect of microwave convective (0.7W/g and 62°C), hot air (62°C), freeze and vacuum drying (94.6 kPa) methods on the quality of osmotically dehydrated cranberries. With all drying methods, they reported that the constant drying rate period is no longer present following osmotic dehydration. This effect was also reported by Piotrowski *et al*., (2000) with strawberries. The fastest drying method was microwave convective, and the longest was for hot air drying at 62°C. All dried samples were judged acceptable by sensory evaluation and the texture of the microwave dried samples scored the closest to commercially available dried cranberries .

Venkatachalapathy and Raghavan (2002) reported that combined osmotic microwave dried strawberry were close to that of freeze-dried product in terms of rehydration characteristics and overall sensory evaluation.

2.6.1 Effects of micro wave drying on drying behaviour

Microwave drying of red curry paste conducted by Pimpen *et al*., (1995) showed three drying period ,i.e. heating up, constant rate and falling rate periods, while hot-air drying exhibited only heating up and falling rate periods. The Page model provided the best prediction for both microwave and hot-air drying processes.

The effects of microwave and hot-air drying methods on drying behaviour of Thai red curry paste were examined in a study conducted by Sudathip *et* a*l*., (1997) It was found that the time required for microwave drying to reduce the moisture content from 2.58 to 0.08g water/g dry matter was 23, 12 and 8 min at 180, 360 and 540W respectively. This was much shorter than that for hot-air drying, which was 240, 180 and 130 min at 60, 70 and 80 °C respectively. An increase in microwave power and drying air temperature shortened the drying time for both processes.

Dogantan and Tuncer (1989) have tried to determine the typical characteristics for drying the red pepper by means of laboratory-type dryer in their study. They observed that the drying temperature for red pepper should be 60°C maximum, and determined that pepper could be burnt at a temperature of 65°C. Meanwhile, optimum speed for air should be 0.5 m/s. Then, it was found that the time for drying could be decreased extensively if red peppers were splitted prior to drying them.

Raghavan *et al*., (1993) carried out some studies on drying of cereal grains by microwave drying process, and specified the advantages and limitations for microwave assisted drying process. Some characteristical changes such as physical, chemical, baking, et. were inspected in a study in which two types of wheat grains with different natural water contents were dried by means of microwave (Gogus *et al*., 1993). Although total protein content was not effected, the functionality of gluten and the time for getting swollen changed gradualy as also perceived by baking characteristics.

The study of Funebo and Ohlsson (1998), in which they inspected drying conditions of apple and mushroom using microwave oven, was accomplished using microwave energy in low levels. Air currents in low levels caused the pepper to become brownish, and the air speed minimum was identified as 1 m/s. They observed that it was possible to decrease the drying times as four factors for mushroom, and two factors for apple only by using microwave assisted hot air drying method.

In his study in which Maskan (2001) inpected the kinetics for color changes of kiwi fruit which was dried using hot air drying, microwave drying and a final drying combination of hot air plus microwave, Hunter L*,a*,b* values, Chroma, Hue angle total color difference and index values for becoming brown in color were used so that kinetical parameters for color changes could be identified therein. It was stated that the drying process which changes three parameters about colour has caused some colour differences towards more dark sections of fruit. It was observed meanwhile that whereas values for L* and b* decreased, a* value increased during drying. Hunter parameters were much more influenced by microwave drying. Kinetic models as zero and first degree were applied to identify changes in colour. It was found enough for identifying L* and b* values in both models. Ozkan et al. (2001) have carried out some studies to dry tomatoes by microwave drying which has not been applied extensively in Turkey, but applied extensively in developed countries in order to make it possible to dry the leguminous plants and cereals particularly in shorter periods of time. The experiments carried out revealed that the tomatoes has dried in shorter periods of time by means of the microwave drying method when compared to other methods; there were no loss in its color, aroma and flavor, and therefore no change in its shape.

Kemahlioglu and Baysal (2002) claimed that a target water content of 17% during first stage of microwave drying should be obtained for drying products to prevent excessive losses of water. At the end of this process which was applied 30 minutes approximately at 71 to 82°C, the product reached at the final water content required within a period of 10 to 20 minutes during microwave drying process.

Panchariya *et al*., (2002) improved an experimental dryer to identify the drying kinetics of black tea. The drying characteristics of the tea were inspected using an environmental air heated to a temperature range of 80 to120^{0}C, and having an air speed of 0.25 to 0.65 m/s. Weights of product; temperature values of dry and wet ampules; and air speed of desiccated air were all recorded during the testing. In their study, some drying data were applied to models such as Lewis, Page, Improved Page, Two-Terms and Henderson and Pabis according to the ratio of differences between first and final water contents, and balance water content. The model Lewis has given better expected values than others.

Silva *et al*., (2006) dried Macadamia nuts by means of microwave energy. The period for drying was measured as much more shorter (4.5 to 5.5 h) than required for drying by conventional hot air drying (in 14 h). Therefore, when recommended application of microwave during drying period was compared to the characteristics obtained using conventional drying process, first was identified as more effective than second for keeping natural characteristics of Macadamia nut.

Tuncer (2006) carried out a study to dry red peppers of spicy-type in driers with microwave bands. The study proved that the quality of pepper dried by microwave method was improved, the time for drying decreased, and so the cost for drying reduced since the energy was used effectively. A project using an industrial type dryer with bands was designed for drying by means of microwave technology.

Wang *et al*., (2007) dried and improved a model for drying apple puree by microwave with thin layers with and without hot air pre-drying, the apple puree with an initial water content of 80% was dried until water contents of 40% approximately were obtained by means of electrical thermal dryer at a temperature of 105^{0}C and with an air circulating speed of 1.2 m/s.

MW drying alone has some major drawbacks that include uneven heating, possible textural damage, and limited product penetration of the MW radiation into the product. Other drying methods can be combined to overcome these drawbacks. For example, the uneven heating of single MW drying can be significantly improved by combined spouted bed drying if the material to be dried is of particulate nature that can be spouted .(Feng & Tang)

In general, MW-related drying can meet the four major requirements in drying of foods: speed of operation, energy efficiency, cost of operation, and quality of dried products (Gunasekaran, 1999).

2.7 Packaging And Storage.

From a processor's point of view, food safety is most important; therefore, the assurance of the integrity of packaged foods is critical to the acceptability of closures and containers (packages). The integrity of a package prevents the biological, chemical, or physical contamination of food from or to the environment. The mechanical properties, especially strength of packaging materials, are also important for protection during distribution and processing of packaged foods. Acceptable barrier properties, on the other hand, would be important in preventing chemical or physical degradation of food including gain or loss of flavours and aromas and changes in colour and texture. The performance of packages depends on the packaging material properties (after conversion) and the converting processes used to manufacture the package. Many materials can be modified to improve package performance. Generally, packaging materials can be grouped in four major categories: polymers, metals, paper and paperboard, and glass.(Hotchkiss *et al*., 1981)

The selection of packages and packaging materials should be based primarily on considerations of food safety, followed by quality, cost, legal and international issues. Important properties of common packaging materials generally are mechanical, optical, and thermal properties (Felix *et al*., 1990).

Leafy vegetables (curry leaves and drumstick leaves) were dehydrated in cabinet drier at 58±2°C and packed in four packaging materials (200 gauge and 400 gauge LDPE, 200 gauge HDPE and 150 gauge PP) and stored at room temperature (RT) and low temperature (LT) for 3 months to evaluate best package and storage temperature for maximum retention of nutrients in leafy vegetables during storage. HDPE (200 gauge), followed by storage at LT (7±1°C), was found to be good for higher retention of β-carotene, ascorbic acid, chlorophyll content, rehydration ratio, sensory score and less moisture and non-enzymatic browning (NEB) in dehydrated vegetable leaves during 3 months of storage.(Singh and Sagar, 1990)

Polypropylene is a clear glossy film with high strength and is puncture resistant. It has moderate permeability to moisture, gases and odours, which is not affected by changes in humidity. It stretches, although less than polyethylene. (Paine *et al*., 1992).

Low-density polyethylene is heat sealable, inert, odour free and shrinks when heated. It is a good moisture barrier but has a relatively high gas permeability, sensitivity to oils and poor odour resistance. It is less expensive than most films and is therefore widely used. High-density polyethylene is strong, thick, less flexible and more brittle than low-density polyethylene and has low permeability to gases and moisture. It has higher softening temperature (121ºC) and can therefore be heat sterilised. Sacks made from 0.03 0.15mm high-density polyethylene have a high tear strength, penetration resistance and seal strength. They are waterproof and chemically resistant and are used instead of paper sacks (Paine *et al*., 1991).

Aluminium foil is produced by a cold reduction process in which pure aluminium (purity greater than 99.4%) is passed through rollers to reduce thickness to lesser than 0.152 mm and annealed to give dead folding properties. Advantages of foil include ; a good appearance , dead folding , ability to reflect radiant energy and an excellent barrier to moisture and gases . Foil (more than 0.015 mm thick) is totally impermeable to moisture, gas, light and microorganisms (Sudheer, 1998).

Packaging is a means of providing the correct environmental conditions for food during the length of time it is stored and/or distributed to the consumer. A good package has to perform the following functions:

• It must keep the product clean and provide a barrier against dirt and other contaminants.
• It should prevent losses. Its design should provide protection and convenience in handling, during transport, distribution and marketing. In particular, the size, shape and weight of the packages must be considered.
• It must provide protection to the food against physical and chemical damage (eg water and water vapour, oxidation, light) and insects and rodents.
• It must provide identification and instruction so that the food is used correctly and have sales appeal. (Kirwan, 1999)

Food packaging must protect against several factors that will make the food unsuitable for consumption. Deteriorative mechanisms can be divided into four types: biological agents, mechanical damage, chemical degradation, and physical damage. Biological agents include microorganisms, insects, and rodents. Protection from these takes several forms—the primary one being a physical barrier. For rodents and insects, both of which can penetrate all but glass and metal, barrier is critical (Sudheer, 1998)

The dried products can be packed in airtight jars, plastic or glass bottles, or plastic bags The container should be filled with the dried produce as full as possible to remove air before sealing. Heat- or vacuum-sealing plastic bags can further extend shelf life of the dried product. The packed produce should be kept in a cool, dark, dry place (Kyi, 2007).

The food products like dried vegetables, cereals and some ready mixes have very low moisture content. So they don't need high barrier packaging materials. A single structure polypropylene (PP) of thickness more than 75 microns, laminate of metalised polyester (PET) of thickness more than 12 microns and a heat sealable layer of low density polyethylene (LDPE) of thickness 75 microns are suitable for a shelf-life of at least 6 months. Triple layer laminate of paper/12 *micron* aluminium foil/ LDPE offers better quality, but its cost is higher.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter deals with materials used and the methods adopted for the various, pre-treatments before drying, drying methods followed, packaging and organoleptic cum quantitative analysis of dried curry leaves.

3.1 Collection of Fresh curry Leaves.

The Curry Leaves were bought from the local vegetables markets of Tavanur, Malapuram district and also from the trees in KCAET campus.

3.2 Pre-Treatments.

The quality of the final product after processing depends on the quality of the fresh leaves. Therefore pre-treatments such as cleaning, washing, blanching etc. were carried out.

3.2.1 Cleaning and washing.

The leaves were separated from the stalks washed under running water . The water was then drained off.

3.2.2 Blanching

The leaves were then blanched in hot water at 50 ºC containing 0.1 per cent of citric acid for 2 minutes. Afterwards the leaves were spread on a for few miniutes for cooling. The leaves were then washed in cool, clean water for the removal of traces of citric acid.

3.3 Drying.

In this study inorder to asses the drying quality of conventional and microwave drying. Methods such as sun drying and hot air oven drying of curry leaves were carried out for comparison.

3.3.1 Sun drying.

Leaves after blanching were spread evenly over a perforated tray. The trays were then kept on clean concreted yard with full sunshine throughout the day (Plate 3.1). The trays were kept raised from the ground using bricks to proper aeration. Sun drying was carried out for 4 hours.

Plate No. 3.1 Sun Drying Of Curry Leaves

3.3.2 Hot air drying.

A hot air oven (605 x 605 x 910mm) inside dimension and made of stainless steel, with digital display cum controller and air circulating fan was used for study (Plate 3.2). The leaves were spread on stainless steel tray and were kept inside the hot air oven for 2 hours at 50 to 55 ºC.

Plate no. 3.2 Hot Air Oven

3.3.3 Microwave drying

A domestic microwave oven (model: Kenstar – 9808 series) having outside dimensions 464 x 274 x 325mm was used for conducting microwave drying studies (Plate 3.3). Leaves were spread uniformly in a single layer on glass plate of the oven and were dried under three power levels ie, 40, 50 and 60 percent for ten minutes.

Plate no. 3.3 Microwave oven

3.4 Quantitative Analysis of Green and Dried leaves.

The major constituents of curry leaves such as water, volatile oil , calcium, ascorbic acid , fibre etc. were estimated as per the procedure mentioned as dscribed by Renganna *et al*., (1986).

3.4.1 Moisture content

Moisture content was determined by using oven drying according to AOAC (1984) method. The samples were kept in the oven at 130±2 ^{0}C for 2 hours . Weight of samples before (w_1) and after (w_2) drying were noted.

$$\text{Moisture (\%wb)} = \frac{w1 - w2 \times 100}{w1}$$

,

w_1 = weight of sample before drying

w_2 = weight of sample after drying.

3.4.2 Volatile oil

The volatile oil content was estimated by distillation method using Clevenger apparatus.(plate 3.4)

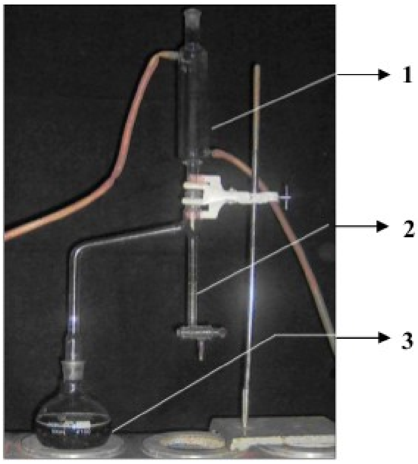

Plate no. 3.4 Clevenger apparatus

1. Condenser
2. Clevenger Apparatus (oil collected)
3. Round Bottom Flask (Sample + Distilled water)

About 50 g leaf powder and 300 ml distilled water were taken in a round bottom flask of the apparatus. The cevenger was then fitted. On boiling, the oil was collected in the receiver of the apparatus which contained distilled water. The distillation was carried out for 2 hours. Volume of oil collected was noted and its weight was found. The volatile oil in present was expressed as,

$$\text{Volatile oil, \%} = \frac{V \times 100}{W}$$

Where, V = Weight of oil collected, g

W = Total weight of the sample, g

3.4.3 Crude fibre of food

Crude fibre consists of cellulose, variable proportion of hemicellulose and highly variable proportion of lignin along with some minerals. Estimation is based on treating the moisture and fat free sample successively with dilute alkali. During these steps, oxidative hydrolytic degradation of the native cellulose and considerable degradation of lignin occur.The residue obtained after final filtration is weighed, incinerated, cooled and weighed again. The reagents were: 0.255N(±0.005) H_2SO_4 - Mix 6.79ml of H_2SO_4 in water and make up to 1 litre.(1.25%), 0.313N(±0.005)NaOH -Dissolve 12.5g NaOH in water and make up to 1 litre.(1.25%). The loss in weight gives crude fibre content.

2g of the dried sample was ground and boiled with 200ml of H2SO4 for 30 minutes.The mass was then filtered through muslin cloth and washed with boiling water until washings are no longer acidic. This was then boiled with 200ml NaOH for 30 minutes. Filter through muslin cloth again and washed with 25ml of boiling 1.25% H2SO4, 350ml portion of water and 26ml alcohol. Remove the residue. Transfer to ashing dish(W1). Dry the residue for 2hour at 130±2°C. Cool the dish in the desiccator and weigh (W2). Ignite for 30 minutes at

600±15°C. Cool in a desiccator and reweigh (W3).

Calculation

% crude fibre = $(W2 - W1) - (W3 - W1)/weight\ of\ sample$

3.4.4 Ascorbic acid

The reduction of dye 2,6 dichloro phenol indophenol by an acid solution of ascorbic acid forms the basis of the estimation. In the absence of interfering agent, the capacity of an extract of the sample to reduce a standard solution of the dye is directly proportional to ascorbic contents. The reagents used were 4% oxalic acid, standard ascorbic acid, 2,6 dichlorophenol indophenol dye. The standardisation of the dye was carried out by taking 5ml of standard ascorbic acid to which 5ml of oxalic acid was added. This was titrated with dye solution taken in burette to a pink colour which should persist atleast for 15 seconds.

Dye factor = 0.5/Titre value

Ascorbic acid content of leaf juice was estimated by making up 10 ml of leaf juice to 100 ml with 4 % oxalic acid. Pipette 10 ml of the made up solution into a conical flask. This was titrated against the dye taken in a burette to a pink end point, which should persist for at least 15 seconds. The titration was repeated to obtain concordant values (d).

Ascorbic acid (mg) present in 100 ml of leaf juice =

dye factor * d* volume made up*100 /(volume taken * weight of sample)

3.4.5 Determination of calcium.

The reagents used were 4% ammonium oxalate,0.01N pottassium permanganate, Strong ammonia, Glacial acetic acid and 2N sulphuric acid. 10 ml of ash solution was made upto 100ml with distilled water. Add a few drops of methyl red indicator. Neutralise the mixture with concentrated ammonia till pink colour changes to yellow. The solution was boiled and 10 ml of 4% ammonium oxalate was added. Boil the mixture for few minutes. A few drops of glacial acetic acid weree added till the colour turns to pink. The mixture was kept in a warm place. Allow precipitate to settle. The supernatent was tested by adding 5 drops of ammonium oxalate solution to ensure the completion of precipitation.The precipitate was filtered through whatman no:40 or 42 filter paper and washed with ammoniacal water (3% NH_3) till free of oxalate. The precipitate was transformed to a beaker by piercing a hole in the filter paper and pouring 5 – 10 ml of 2N H_2SO_4 . The solution was heated at about 70^0C and titrated against 0.01N $KMnO_4$ solution. The Ca content in 100 ml of ash solution was found as follows.

1ml of 0.01N $KMnO_4$ = 0.2 mg of Ca

t ml (titrate value) of $KMnO_4$ = 0.2t mg of calcium

Ca present in 10 ml of ash solution = 0.2t mg

Ca content in 100 ml of ash solution = (0.2t * 100) / 10 mg of calcium

3.5 Colour

Hunter lab colour flex meter (Plate 3.5) was used for the measurement of colour of the dried curry leaves. It works on the principle of focussing the light and measures energy reflected from the sample across the entire visible spectrum. The colour meter uses filters which rely on "standard observer curves" that define the amount of red, green and blue colours. The primary lights required matching a series of colours across the visible spectrum and mathematical model used to describe the colours are called as Hunter model. It provides reading in terms of L, a and b. Where, luminance (L) forms the vertical axis, which indicates whiteness to darkness. Chromatic portion of the solids is defined by: a (+) redness, a (-) greenness, b (+) yellowness, and b (-) blueness.

The colour of the curry leaves were measured by using CIELAB scale at 10° observer at D_{65} illuminant. Before measuring the colour of the samples, the instrument was standardized by placing black and white standard plates. The sample colour was measured by filling the leaves in the transparent cup without any void space at the bottom.

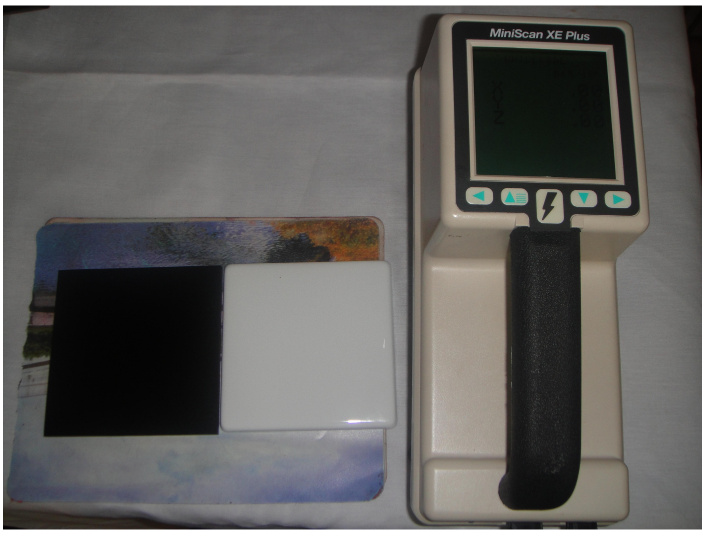

Plate No. 3.5 Hunter Lab Colour Flex Meter

3.6 Sensory Evaluation.

The curry leaves obtained after drying employing different treatments as described were used for the preparation of 'Sambharam' with the traditional ingredients whose quantities were fixed in all the samples prepared. The main ingredients of the drink were butter milk , salt and curry leaves. six samples were choosen each containing fresh, microwave at power level of 40, 50 and 60 ; sundried and hot air oven dried. A heterogenous population consisting of eight people with different age group and sex were selected for sensory evaluation. They ranked the samples according to overall flavour and acceeptability and other characteristics of the prepared 'Sambharam'.The specimen score card is shown in Fig 3.1.

Plate no 3.6 Sensory evaluation of 'Sambharam'

Sensory Analysis questionnaires

(Evaluation of flavour of curryleaves in sambharam)

Ranking test

Name ....
Panelist # ....

Date 20 /12/ 2011

Attribute being tested: Flavour of curryleaves

Instructions: You have been presented with six samples of sambharam. Inspect the samples for overall flavour in the order presented below and rank the samples in order of flavour of curryleaves ,indicate with a check mark against corresponding coloumns.

SAMPLE	Ranking of samples per taster, e.g. 1st, 2nd, 3rd						
	1st	2nd	3rd	4th	5th	6th	Comments
1							
2							
3							
4							
5							
6							

Which sample is most preferable:

Overall conclusions:

Fig . 3.1 Score Card For Sensory Analysis

3.7 Packaging Studies of MW Dried Curry Leaves.

Based on the previous studies , the microwave dried leaves with optimum parameters were selected for packaging studies. They were packed in three diffrent types of packaging materials such as low density polyethelene (LDPE), polypropelene (PP) and aluminium foil(AF) at room temperature. The packets were sealed by using a hot bar sealing machine. Before packing quantitative and quantitative analysis of leaves were found. After every 15 days these test were repeated. The tests were conducted for a storage period of 30 days.

RESULTS AND DISCUSSION

CHAPTER IV
RESULTS AND DISCUSSION

In this chapter results of the studies of microwave drying are discussed. The quality and shelf life of microwave dried curry leaves are presented . the packaging studies of the curry leaves are also dealt with.

4.1 Pre- Treatments

4.1.1 Blanching

Blanching with 0.1% citric acid at 50ºC for 2 minute was found to improve the colour and reduces the activity of enzymes. Also it was revealed that curling of leaves while drying were reduced due to blanching operation . Blanched curry leaves after drying have bright green colour. Colour was found to be retained even after packaging and storage .

4.2 Drying studies of curry leaves

Drying is the removal of moisture content from a commodity to increase its shelf life. Curry leaves are perishable commodity which undergoes reduction in quality when kept at normal atmospheric condition. To increase its shelf life, moisture content is to be decreased. By reducing moisture content to optimum level, its water activity is reduced so that the action of pathogenic microorganisms are inhibited. Various drying techniques are used for drying curry leaves. In this study microwave drying of curry leaves were analysed under various variable levels of microwave power as mentioned in section 3.3.3. based on the preliminary studies the time of drying was fixed at 10 min . In order to asses the quality of the microwave dried curry leaves. The quality characteristics were also compared with that of hot air and sun dried leaves.

4.3 Quality Characteristics Of Dried Curry Leaves

Quantitative analysis of quality characteristics of dried curry leaves described in chapter 3 and the results are presented in Table 4.1.

4.3.1 Moisture content

Moisture content in wet basis was found to decreased upto 2.89% after MW drying at power level of 60. This moisture content was found to be safe for storage and further processing. Whereas moisture content of the hot air oven and sun dried samples could be reduced to 4.89 and 9.8 percent only. (Plate 4.1)

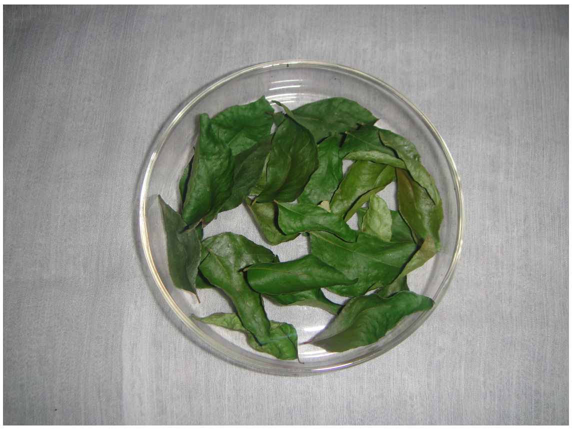

Plate No 4.1 Curry Leaves Before And After Microwave Drying

4.3.2 Oil content

Flavour and aroma of curry leaves are due to presence of essential oil in curry leaves . It was found that the oil content in the microwave dried samples were close to that of the fresh samples leading to the conclusion that microwave drying retain the fresh like flavour and aroma. It may also be noted that the minimum loss was found at power level of 60. The hot air and sun dried samples showed high losses of oil.

4.3.3 Vitamin C

It may be seen from the Table 4.1, the microwave drying retain the vitamin c without significant losses whereas conventional methods resulted in high losses of vit. C. The hot air and sun dried samples showed vit.c content of 29.4 and 23.1 mg per 100 g, whereas microwave oven dried at P-60 level showed 3.2 mg per 100 g.

4.3.4 Calcium

Calcium is an important mineral found in curry leaves. It was found from the studies that calcium content was not significantly affected by drying process.

4.3.5 Fibre

It was also found that fibre content of the curry leaves were not affected by drying process, whatever the method be.

Table 4.1 Quality Characteristics Of Dried Curry Leaves

Quality characteristics	Fresh	MW oven dried			Hot air oven dried	Sundried
		P40	P50	P60		
M.C (%wb)	64.9	3.97	3.04	2.89	4.89	9.8
Oil content (%)	0.5	0.45	0.45	0.48	0.3	0.28
Vit C (mg/100g)	33.3	33.3	33.2	33.2	29.4	23.1
Calcium(mg/100g)	816.45	816.45	816.45	816.45	816.45	816.45
Fibre (%)	6.3	6.3	6.3	6.3	6.3	6.3

4.4 Drying Characteristic Curves.

In order to establish the drying characteristics of the microwave dried curry leaves, drying studies were carried out and the resultant data were plotted . The characterisic curves were obtained using 'Microsoft EXCEL' software . The equation of fit were established and the coefficientsof determination were found to establish the fitness of data.

Table 4.2 Drying data for MW drying of curry leaves at P-40

Time (min)	Moisture removed(g)	Moisture present in the sample(g)	Moisture content(%)
0	0	25.3	65
1	2.6	22.7	58.35
2	5.9	19.4	49.71
3			
4	9.1	16.2	41.64
5	12.5	12.8	32.9
6	16.1	9.2	23.6
7	19.3	6	15.24
8	20.4	4.45	7.98
9	21.6	3.19	5.34
10	22.7	2.6	3.97

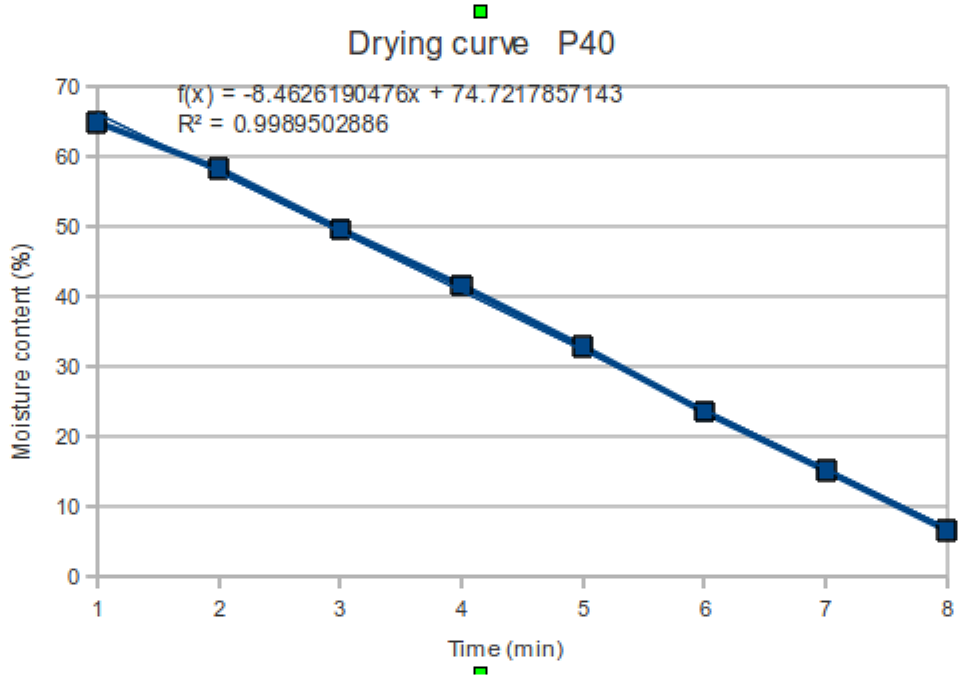

Figure 4.1 Drying curve for MW drying of curry leaves at P-40

Table 4.3 Drying data for MW drying of curry leaves at P-50

Time (min)	Moisture removed (g)	Moisture present in sample (g)	Moisture content(%)
0	0	46.55	64.90
1	6.6	39.95	61.36
2	11	35.55	59.15
3	16.4	30.15	54.52
4	21.7	24.85	49.70
5	29.1	17.45	40.96
6	34.1	12.45	39.15
7	39.9	6.56	20.62
8	43.8	2.75	13.95
9	44	2.55	5.80
10	44.8	1.75	3.04

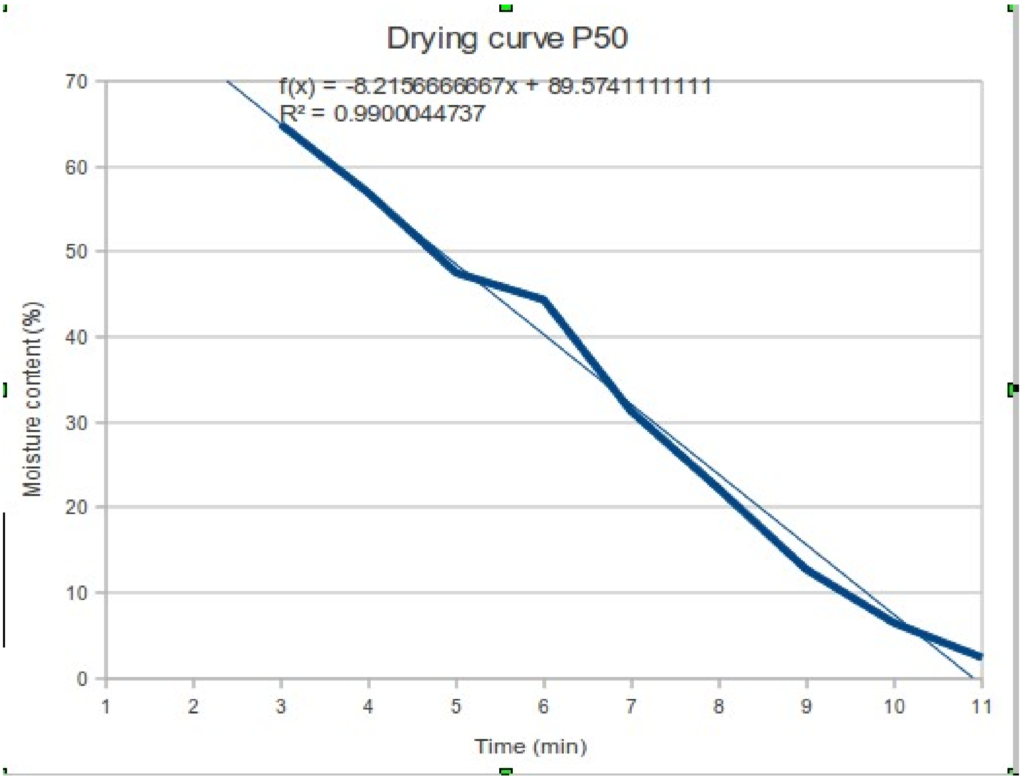

Figure 4.2 Drying curve for MW drying of curry leaves at P-50

Table 4.4 Drying data for MW drying of curry leaves at P-60

Time(min)	Moisture removed(g)	Moisture present in sample(g)	Moisture content(g)
0	0	32.2	64.9
1	4	28.2	56.85
2	8.6	23.6	47.5
3	10.2	22	44.35
4	16.7	15.5	31.25
5	21.2	11	22.17
6	25.9	6.3	12.7
7	29	3.2	6.45
8	31	1.2	3.41
9	31	1.2	3.41
10	31.6	0.6	2.89

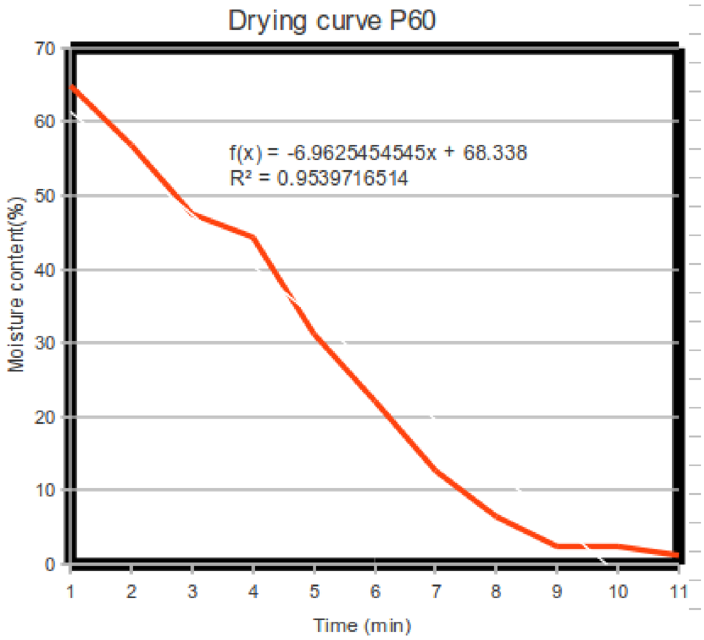

Figure 4.3 Drying curve for MW drying of curry leaves at P-60

The drying data and drying curves for microwave dried curry leaves at power levels of 40, 50 and 60 are shown in table 4.2, 4.3 and 4.4, figure 4.1, 4.2 and 4.3 respectively. In general, the moisture content reduced linearly with time for all treatments. But the moisture content reduced to 2.28%(wb) at P-60 whereas it was reduced to 3.57 and 3.04% only for the treatments P-40 and P-50 respectively. The equations of fit and R^2 values of the obtained curves are presented in Table 4.5.

Table 4.5 Time dependence of moisture content of microwave dried curry leaves.

Sl. No.	Treatments	Equation	R^2
1	P-40	**M.C = - 8.46t + 74.72**	**0.98**
2	P-50	**M.C = - 8.21 t + 89.5**	**0.99**
3	P-60	**M.C = - 6.96 t + 68.33**	**0.95**

4.5 Sensory Evaluation.

As mentioned in section 3.6, the sensory evaluation of the sambharam prepared using curry leaves dried by microwave drying, hot air drying and sundrying were carried out and they were compared with that of sambharam prepared by fresh curry leaves.

Table 4.6 Sensory Evaluation Of 'Sambharam' Prepared By Dried Curry Leaves

Subject	P - 60	Hot air oven	P – 50	Fresh	Sundried	P – 40
1	3	5	6	1	4	2
2	3	5	6	1	4	2
3	4	6	5	1	3	2
4	3	5	6	2	4	1
5	3	5	6	1	4	2
6	3	6	5	1	4	2
7	3	6	5	2	4	1
8	4	6	5	2	3	1

The results are presented in Table 4.5. It may be revealed from the results that the scores of the sambharam prepared by treatment P-40 and p-60 are superior and close to the scores of those prepared by fresh curry leaves.

4.6 Packaging of MW oven dried curry leaves

The MW oven dried curry leaves were filled and sealed in the packaging materials such as Polypropelene(PP), Aluminium foil and LDPE. Quantitative analysis of the quality charctristics were carried out the samples before packaging and at intervals of 15 and 30 days.Results of analysis are tabulated in table 4.7.

Table 4.7 Quality Characteristics Of Microwave Dried Samples

Packaging materials.	No. of days after packag-ing. (days)	Power level (%)											
		P 40				P 50				P 60			
		Vitamin C(mg/100g)	Oil content (%)	Calcium content(mg/100g)	Fibre content (%)	Vitamin C(mg/100g)	Oil content(%)	Calcium content (mg/100g	Fibre content(%)	Vitamin C(mg/100g)	Oil content (%)	Calcium content(mg/100g	Fibre content(%)
Polypropylene	0	33.3	0.9	810.85	6.3	33.3	0.8	816.12	7.02	33.4	1	806.12	6.17
	15	33	0.9	810.85	6.3	32	0.8	816.12	7.02	32	1	806.12	6.17
	30	29.8	0.9	810.85	6.3	29	0.8	816.12	7.02	31.8	1	806.12	6.17
LDPE	0	33.3	0.85	821.4	6.7	32	0.9	818.56	6.8	32	0.9	824.19	7.14
	15	33.3	0.85	821.4	6.7	32	0.9	818.56	6.8	31.5	0.9	824.19	7.14
	30	33.2	0.85	821.4	6.7	32	0.9	818.56	6.8	31.2	0.9	824.19	7.14
Aluminium foil	0	33	0.9	816.45	7.09	31.5	0.8	819.33	6.2	32.3	0.8	815.45	6.57
	15	33	0.9	816.45	7.09	31.5	0.8	819.33	6.2	32	0.8	815.45	6.57
	30	32.4	0.9	816.45	7.09	31	0.8	819.33	6.2	32	0.8	815.45	6.57

It may be revealed that the curry leaves stored in LDPE packaging showed minimum loss of quality. Among the treatments studies, the dried leaves at power level 60 showed maximum quality retention throughout the 30 days storage life studied. The vitamin C loss was maximum in PP and minimum in LDPE, whereas variation in oil content was not significant in all the packaging material studied throughout the storage period. No significant changes were noticed in the calcium and fibre content of the dried leaves packed in various packaging materials throughout the storage period.

It may be concluded for the above findings that drying of curry leaves at a power level of 60 for 10 minutes was found to be optimum and produced dried leaves of optimum quality in terms of oil content, vitamin C, calcium and fibre content. The drying characteristic curves were also obtained and plotted. The microwave drying was also compared with conventional hot air and sundrying methods and was found to be efficient and cost efficient and produces quality curry leaves retaining fresh like characteristics with increased shelf life.

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The curry leaves (*Murraya koenigii*) a green leafy vegetable, is also been used as spice after its drying. They impart health benefit by providing the much needed dietary essential minerals and vitamins to the human diet. Fresh green curry leaves contains about 65 -75% water. They wilt and become inedible in a day or two without refrigeration. However, the post harvest and nutritional losses occur during handling. Drying makes curry leaves available year round. The challenge of drying is to reduce the moisture content to a certain level where microbiological growth will not occur while maintaining high nutrient value. Based on the above facts, an investigation was undertaken to study the effect of microwave drying of curry leaves and also to study its packaging.

In this study we used three drying methods viz., sun drying, hot air oven drying and MW drying. The quality of the dried curry leaves were was expressed in terms of moisture content, oil content, ascorbic acid, calcium and fibre content and also cooking quality through sensory evaluation.

In the light of above literature, results obtained in present study are summarized below:

- Pre-treatment such as blanching gives better colour retention to curry leaves during drying.
- In this study microwave drying of curry leaves were analysed under various variable levels of microwave power, based on the preliminary studies the time of drying was fixed at 10 min. Moisture content in wet basis was found to decreased upto 2.89% after MW drying at power level of 60.
- . It was found that the oil content in the microwave dried samples were close to that of the fresh samples leading to the conclusion that microwave drying retain the fresh like flavour and aroma.
- It was also found that fibre content of the curry leaves were not affected by drying process, whatever the method be.

- The microwave drying retain the vitamin c without significant losses and calcium content was not significantly affected by drying process.
- It may be revealed from the results that the scores of the sambharam prepared by treatment P-40 and p-60 are superior and close to the scores of those prepared by fresh curry leaves.
- The MW oven dried curry leaves were filled and sealed in thee packaging materials such as Polypropylene(PP), Aluminium foil and LDPE. Quantitative analysis of the quality characteristics were carried out. It showed the curry leaves stored in LDPE packaging showed minimum loss of quality.

REFERENCE

REFERENCE

AOAC (1990) Official methods of Analysis, 15th edn. Association Of Official Analytical Chemist, Washington, DC.

Bajaj, M., Aggarwal, P., Minhas, K.S. and Sidhu, J. S., 1993, Effect of blanching treatments on the quality characteristics of dehydrated fenugreek leaves. J. Food Sci. Tech.,30 (3): 196-198.

Bhosle, B. S. and Arya, A. B., 2004, Effect of different modes of drying time of selected vegetables. The Indian J. Nutr. Diet., 41(7): 293-298.

Birar, R. M., Ferande, V. R. and Unde, P. A., 2001, Effect of pretreatments on quality of dehydrated fenugreek (methi). Beverage and Food World, 28(12): 23-24.

Brazilian Journal of Chemical Engineering 2005:22(2):195–201

Chowdhury A R, 'Essential oil from the leaves of Murraya koenigii', National Seminar Research and Development in Aromatic Plants: Current trends in biology, uses, production and marketing of essential oils, Lucknow, Central Institute of Medicinal and Aromatic Plants, 1999.

Cui Z-W, Xu S-Y, Sun D-W. Dehydration of garlic slices by combined microwave vacuum and air drying. Drying Technology 2003: 21

Fathima A, Begum K. and Rajalakshmi D. (2001) Microwave Drying of selected greens and Nutrition 56: 303-311 Prakesh V, Natarajan CP. Studies on curry leaf (Murraya koenigii L.). J Food Sci Tech. 1974; 11: 285-86.

Gupta, D. K., Baburao, N. and Jayaraman, K. S., 1999, Improvement in rehydration and shelf life stability of hot air dried and sun dried cabbage by pre-drying treatment. Indian Food Packer, 53(6): 51-60.

Gupta, S., Jyothi, L. A., 2003, Compositional changes in green leafy vegetables on dehydration. Proceedings of International Food Conference, VG-28.

Hiremath SM, Madalageri BB, Basarkar PW. Composition of curry leaf (Murraya koenigii Spreng) oil during leaf growth. Indian Perfum. 1998; 42: 58-59.

I. A. Ozkan, B. Akbudak, and N. Akbudak, "Microwave drying characteristics of spinach", J. Food Eng., 2007, 78, 577-583.

Kowsalya, S., and Vidhya, M. R., 2004, Nutritive value of selected dehydrated green leafy vegetables. The Indian J. Nutr. Diet., 41: 279-286.

Khan B.A., A. Abraham, and S. Leelamma S. 1997. Anti-oxidant effects of curry leaf, *Murraya koenigii* and mustard seeds, Brassica juncea in rats fed with high fat diet. Indian J. Expt. Biol. 35(2):148–150.

Lakshmi, B. and Vimala, V., 2000, Nutritive value of dehydrated green leafy vegetable powders. J. Food Sci. Tech., 37 (5): 465-471.

M. Maskan, "Drying, shrinkage and rehydration characteristics of kiwifruits during hot air and microwave drying", J. Food Eng., 2001, 48, 177-182.

Omankutty Amma M, Rajaraman K, Sankarikutty B, Sumathikutty MA, Padmakumari KP, Narayanan CS. Processing of curry leaves. Indian Food Packer. 1984, pp 32-36.

Sunjka P S , Raghavan GSV, Rennie TJ, Orsat V, Phaphuangwittayakul W and Terdtoon P. Overview of new techniques for drying biological materials with emphasis on energy aspects. .

Raghavan, G.S.V., V. Orsat and M.S.Venkatesh. 2005. Microwave Processing of Foods. Stewart Postharvest Review 1(2:3):1-8.

Ranganna S, Handbook of Analysis and Quality Control for Fruit and Vegetables Product, 2nd edn (Tata McGraw Hill Publication Co. Ltd, New Delhi) 1986, 112.

Sharma GP and Prasad S. Optimization of process parameters for microwave drying of garlic cloves. Journal of food engineering 2006: 75 (4):441–446.

Singh and Sagar Packaging And Storage Of Dehydrated Leafy Vegetables Vol. 69, October 2010, pp. 785-789.

Sukanya, M.H., Rao, S. and Naik, R., 1995-96, Practices of sun drying and storage of different vegetables for domestic purpose. Karnataka J. Agric. Sci., 8(4): 433-436.

Vijayalakshmi, P. and Devadas, R. P., 1994, Enhancing the nutritive value of convenience foods by incorporating green leafy vegetables. The Indian J. Nutr. Diet., 31: 333-338.

Venkatachalapathy, K and G.S.V. Raghavan. 1997. Osmotic and Microwave drying of blueberries. Proceedings of the 32 Microwave Power Symposium, Ottawa, Canada. International Microwave Power Institute, USA.

Vijayaraghavan, K., 2006, Iron deficiency anaemia in India and its control. The Indian J. Nutr. Diet., 44: 107-114.

STUDIES ON MICROWAVE DRYING AND PACKAGING OF CURRY LEAVES

By

Amitha M. Anand.

Chippy Jasmine Francis.

PROJECT REPORT
Submitted in partial fulfillment of the requirement for the degree

Bachelor of Technology

In

Agricultural Engineering

Faculty of Agricultural Engineering and Technology
Kerala Agricultural University

Department of Post-Harvest Technology and Agricultural Processing
KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY
TAVANUR - 679 573, MALAPPURAM
KERALA, INDIA

2011

ABSTRACT

The curry leaves (*Murraya koenigii*) a green leafy vegetable, is also been used as spice. Leaves are especially good sources of vitamin A, vitamin C, and folic acid vitamins most likely to be lacking in the diet. They impart health benefit by providing the much needed dietary essential minerals and vitamins to the human diet .The demand for fresh and dried curry leaves has considerably increased over the last two decades. Fresh green curry leaves contains about 75% water. They wilt and become inedible in a day or two without refrigeration. However, the post harvest and nutritional losses occur during handling, transportation, processing and storage, which have gone up to 40 per cent annually. When they are dried to less than 10 % water they remain good to eat for several months. Based on the above facts, an investigation was undertaken to study the effect of microwave drying of curry leaves and also to study its packaging. Fresh and mature curry leaves procured from market were subjected to three different drying methods namely;. sun drying, hot air oven drying and MW drying. The study involves mainly three steps: 1) drying studies and, 2) post drying analysis curry leaves, 3) packaging of dried curry leaves. The first major step involved is giving pre-treatments such as washing and blanching to the leaves. After that samples were by above stated methods. MW dried curry leaves reached the desired moisture content faster as expected. The second step involved the quality analysis of dried leaves in terms of moisture content, oil content, ascorbic acid, calcium and fibre content and also cooking quality through sensory evaluation. The oil content in the microwave dried samples were close to that of the fresh. Fibre content of the curry leaves were not affected by drying process, MW drying retain the vitamin c and calcium content without significant losses. It may be revealed from the results that the scores of the sambharam prepared by treatment P-40 and p-60 are superior. The MW oven dried curry leaves were filled and sealed in thee packaging materials such as Polypropylene(PP), Aluminium foil and LDPE. After quantitative analysis of the quality characteristics, it showed the curry leaves stored in LDPE packaging showed minimum loss of quality.