MODIFIED ATMOSPHERIC PACKAGING OF FRIED BITTER GOURD

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2009

DECLARATION

We hereby declare that this project report entitled ***"MODIFIED ATMOSPHERIC PACKAGING OF FRIED BITTER GOURD"*** 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 to us of any degree, diploma, associateship, fellowship or other similar title of another University or Society.

Place: Tavanur

Date:

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CERTIFICATE

Certified that this project report entitled ***"MODIFIED ATMOSPHERIC PACKAGING OF FRIED BITTER GOURD"*** is a record of project work done jointly by **Asha Thomas, Deepthy K.R. and Susha Lekshmi S.U**. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar title of another University or Society.

Place: Tavanur

Date :

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Deepthy, K.R.

Susha Lekshmi, S.U

Dedicated to

Our Loving Parents

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SYMBOLS AND ABBREVIATIONS

@	at the rate of
%	percentage
/	per
^0C	degree Celsius
µl	micro litre
µm	micro meter
AICRP	All India Co-ordinated Research Project
APEDA	Agricultural and Processed food products Export Development Authority
cal	calorie
cc	cubic meter
cm	centimeter
CO_2	Carbon dioxide
et al.	and other people
etc.	etcetera
EVA	Ethylene Vinyl Acetate
h/day	hour per day

FAO	Food and Agricultural Organization
g	gram
g/h	gram per hour
g/kg	gram per kilogram
hrs	hours
HDPE	High Density Polyethylene
i.e	that is
J.	journal
KAU	Kerala Agricultural University
kg	kilogram
kg/m^3	kilogram per cubic meter
kPa	kilopascal
LDPE	Low Density Polyethylene
MAP	Modified Atmospheric Packaging
mcg	micro calorie gram
mg	milligram
min.	minutes
ml	millilitre

mm	millimeter
m/s	meter per second
N_2	Nitrogen
N	normal
nl	nano litre
No.	number
O_2	Oxygen
OPP	Oriented Polypropylene
PE	Polyethylene
PHT & AP	Post Harvest Technology and Agricultural Processing
PP	Polypropylene
PS	Polystyrene
PVC	Poly Vinyl Chloride
ppm	parts per million
RH	relative humidity
s	second
t/ha	tonnes per hectare
wb	wet basis

Introduction

CHAPTER 1

INTRODUCTION

India is the fruit and vegetable basket of the world. India being a home of wide variety of fruits and vegetables holds a unique position in production figures among other countries. India holds the second position in both fruit and vegetable productions in the world (FAO, 2001). India's exports of fresh fruit and vegetable have increased from Rs.1658.72 crores in 2005-06 to Rs.2411.66 crores in 2006-07(APEDA). Recent regional economic growth and changes in dietary patterns have made both the production and consumption of fruits and vegetables. Among the horticultural crops vegetables have an important position and are a high protective food of dietary complex of human beings. Fruits and vegetables are highly perishable commodities. This is more evident from the fact that losses in both quantity and quality occurs in horticultural crops between harvest and consumption. Due to high water content on fresh horticultural crops, they are subjected to desiccation, mechanical injury and also susceptible to attack by bacteria and fungi, resulting as pathological breakdown. This results in changes in texture, colour, flavour and nutritional value of the food. These changes can render food unpalatable and potentially unsafe for human consumption. The magnitude of the post harvest losses in fresh fruits and vegetables is estimated to be 30-40% in developed countries and 50% in developing country (Farzana, 2006).

The primary role of fruits and vegetables in the diet is to provide vitamins, folic acid and minerals. Bitter gourd (*Momordica charantia L.)* is a popular vegetable of the tropics. Cultivation of bitter gourd is reported throughout India. The fruit is best known for medicinal value in controlling diabetics and other diseases of liver and spleen. Because of these attributes bitter gourd has good demand. Fresh 1 Kg bitter gourd is equivalent to 100 grams of fried bitter gourd for a healthy diet. Many markets carry bitter gourd chips, and these chips often include regional foods and flavours to appeal to the local market. The post-harvest loss of bitter gourd is about25 %(*http:// www. agridept. gov. lk*). Main reason for this much of loss is due to ripening and mechanical damage during transport. Therefore the thrust should be made to preserve food in most effective and useful manner and making them available in time of shortage and out of season and at places away from sites of production.

One of the primary goals of preservation is to convert perishable foods into stabilized product that can be stored for extended period of time to reduce their post harvest loss. Post harvest management determines food quality and safety, competitiveness in the market, and the profits earned by producers. Packaging of fresh fruits and vegetables is one of the most potent marketing tools in the long and complicated journey from grower to consumer. It is an integral part of the techniques used to extend the shelf-life of food products by different methods of preservation. Modified Atmospheric Packaging (MAP) is one of the new trends in the field of packaging. Storage of food in a modified gaseous atmosphere can maintain quality and extend product shelf life by slowing chemical and biochemical deteriorative reactions and preventing the growth of spoilage organisms. The basic technique used to replace air in MAP is gas flushing and compensated vacuum. Modified atmospheric packaging relies on the integrity between the natural process of respiration and gas exchange through the packages (Fonesca *et al*. 2000).

The storage life of fresh bitter gourd under MAP is limited to 14-16 days at 13^{o}C due to it high moisture content. Therefore its shelf life can be improved through value addition. Value addition of bitter gourd can be done by drying. Fried bitter gourd has got great demand in domestic markets.

Considering the above cited advantages in view, a study was conducted in Kelappaji College of Agricultural Engineering and Technology, Tavanur. This encompasses the following specific objectives.

- To conduct studies on Modified Atmospheric Packaging of fried bitter gourd.
- Study on different packaging materials
- Subjective and objective evaluation of bitter gourd
    - Texture analysis
    - Sensory evaluation
    - Microbial load analysis

Review of Literature

CHAPTER II
REVIEW OF LITERATURE

This chapter gives general information on bitter gourd, its chemical composition, drying and frying characteristics, packaging methods and its storage studies. Research done on these aspects are also reviewed and discussed in detail.

2.1 Bitter Gourd

Bitter gourd (*Momordica charantia* L.) or balsampear or karela is a popular vegetable from cucurbitacea family of tropics. Bitter gourd, also called Bitter Melon, has an acquired taste. It is a native vegetable of our country. They are rich in iron, calcium; phosphorous, vitamin A and vitamin C .The fruits, leaves and roots have many beneficial medicinal uses, most notable in regulating diabetes and as a tonic. The fruit is best known for medicinal value; the fruit though bitter is wholesome and estimated as vegetable when physiologically mature. The bitter gourd is reported to be originated in the tropics of the world which is widely distributed in China, Malaysia, India, Thailand, Philippines and Tropical Africa. The skin is bright green in color, the flesh inside is white, and the seeds are small and tender. The vegetable is ridged, and the skin is pebbly in texture. It has a good clinical application to control diabetics. Because of these attributes bitter gourd has good demand.

2.1.1 Climate and season

Bitter gourd is a fast growing warm seasonal climbing annual. The plant is grown mainly for the immature fruits although the young leaves and tips are edible. Any good agricultural soil will produce good crops of bitter melon with proper management practices. A deep, well-drained sandy loam or silt loam is ideal. It may fail or take a long time to germinate if the soil temperature is too low. Bitter Melon seed has hard skin and needs warm or moist soil conditions during germination.

2.1.2 Harvesting and Handling

Bitter gourd requires close attention at harvest time. Normally it takes 15–20 days after fruit set or 90 days from planting for fruit to reach marketable age. However bitter gourd can be harvested at earlier stages depending on the purpose for which it will be used. Fruit should be light green, thick and juicy, and the seeds should be soft and white. A good yield is 10 to 12 fruits per plant, or 5 to 7 tonnes per acre. It is available only during harvesting season due to its perishable nature. So drying, pickling, frying and canning are some methods employed to preserve it.

2.1.3 Nutritive value

Momordica charantia (Cucurbitaceae) is a widely cultivated plant for medicinal and food uses. It has been used extensively in folk medicine as a remedy for diabetes. In Ayurveda, the fruit is considered as tonic stomachic, stimulant, emetic, antibilous, laxative and alterative. It is an excellent source of vitamins B1, B2, and B3, C, magnesium, folic acid, zinc, phosphorus and manganese. It has high dietary fiber juice from the green fruits which is drunk as a remedy for chronic colitis. The fruits of the plants are used in culinary preparations all over the world. The cooked fruit is eaten as a remedy for catarrh, flux, and cough. It is also thought to be an excellent blood purifier, enhances digestion, and stimulates the liver. From the ayurvedic perspective, bitter gourd is excellent for balancing Kapha.

Table 2.1 Nutritional composition of bitter gourd

Energy	25 cal
Moisture	92.4 g
Protein	1.6 g
Fat	0.2 g
Carbohydrate	4.2 g
Calcium	20 mg
Phosphorus	70 mg
Iron	1.8 mg
Carotene	126 mcg
Thiamine	70 mcg
Riboflavin	90 mcg
Niacin	0.5 mg
Vitamin c	88 mg

Source: Medical Research Institute, Colombo

2.1.4 Varieties

Wide spectrum of variability exists in bitter gourd with respect to colour shape, size and spineness of fruits. Kerala Agricultural University has released three high yield variety of bitter gourd namely; Priya, Preethi, Priyanka and Arka Harit are high yielding varieties. Priyanka is recommended for acid alluvial soils of Kerala.. Young immature bitter gourds are the best for cooking. (Package of Practices Recommendations, KAU.2002).

Preethi variety is a high yield (29.5 t/ha), attractive white spiny fruits with light green tinge and medium size. The average weight is 310 g and the average fruit length is 30 cm.

2.2 Pre-treatment studies

Drying of agricultural products is the most widely used method of preservation. It refers to the removal of water from products containing 70 to 95% water. Micro organisms that cause food spoilage and decay cannot grow and multiply in the absence of water.

Shablana *et al.* (2003) conducted a study on the effect of convective drying on apparent density, porosity and moisture diffusivity of potato and apple. During air drying apparent density of apple and potato varied from 676.2 to 839.6 kg/m^3 and 1214 to 1050 kg/m^3 respectively. In both cases porosity increased with decrease in moisture content. Drying temperature in the range of 60 to 80^0C did not have any effect on the degree of pore formation. Within the same temperature the range of effective moisture diffusivity for potato and apple increased drastically.

2.3 Mechanism of frying

Deep fat frying is a complex process involving heat transfer, water diffusion, oil uptake and food textural development. Deep fat frying produces changes in food structure like textural changes, attractive and tasty surface, increased palatability and browning reactions. As the frying proceeds, rapid vapourisation of water occurs. As a result of which the crispness of dry region begins to form at the surface of the food. Towards the end of frying the rate of moisture removal diminishes accompanied by the colour and flavour development.

They depend on oil temperature, frying time, food composition and thermal properties of the food being fried. Upon frying the crispness of bitter gourd chips increases as porosity increases and moisture decreases. The important characteristic of fried food is the crispness of the outer layer of the fried product.

2.3.1 Studies on Frying

Frying alters the eating quality of food. It also provides a preservative effect as the heat treatment destroys microorganisms and enzymes, and there is a reduction in moisture at the surface of the food.

Krokida, *et al*. (2000) conducted a study on water loss and oil uptake as a function of frying time. A relationship between moisture loss and oil adsorption with frying time during deep fat frying of French fries has been developed.The first order kinetic equation model was applied to a wide range of experimental data and its parameters were estimated using non-linear regression analysis. The results showed that oil temperature and thickness of potato strips have a significant effect on oil uptake and moisture loss of French fries, while the use of hydrogenated oil in the frying medium does not affect mass transfer phenomena.

Franco Pedreschi and Pedro Moyano (2005) studied on oil uptake and texture development in fried potato slices. Prior to frying, potato slices were blanched in hot water at 85 ^{0}C 3.5 min. Unblanched slices were used as the control. Control and blanched potato slices (Panda variety, diameter: 37 mm, width: 2.2 mm) were fried at 120, 150 and 180 ^{0}C until reaching moisture contents of 1.8% (total basis) and their texture and oil content were measured periodically. Oil uptake was 15% higher in blanched samples than for control samples after 20 s of frying. Higher the frying temperature, the oil absorption in control samples will be lower. Higher temperatures accelerated these processes; however neither the temperature nor the pre-treatment had a significant effect over the final texture of the fried potato chips.

Taha *et al.* (2005) reported the changes in cottonseed oil during the frying of vegetable products containing chlorophyll. The absorption spectra of cottonseed oil and blend of cottonseed oil and chlorophyll at wave length range 500–700 nm showed a sharp peak at 667 nm for blend of cottonseed oil and chlorophyll which is characteristic of chlorophyll. Heating of blend of cottonseed oil and chlorophyll at the frying temperature resulted in the disappearance of all maxima. The peroxide value of c blend of cottonseed oil and chlorophyll increased due to storage for one month, but decreased when blend of cottonseed oil and chlorophyll was heated for one hr. The results reveal that Tameya when fried in cottonseed oil results in an increase in the absorption spectra of the oil at 670 nm and the start of the appearance of a minor peak at 610 nm. Further heating of the oil resulting from frying Tameya shows that pheophytin in the oil disappears with an increase in heating time. Frying of Tameya in cottonseed oil resulted in a decrease in the peroxide value of the oil

Robertson *et al.* (2006) conducted studies on flavour and chemical evaluation of potato chips fried in sunflower, cottonseed and palm oils. Chips fried in different oils were evaluated by chemical and sensory methods at 2-week intervals during 10 week storage at 31°C. At each evaluation interval, sensory scores did not differ markedly among chips fried in the three oils. Flavour of chips from all oils decreased in quality during storage at the same rate and differed significantly between chips stored 0 and 10 wk. However, quality deterioration was not clearly defined as rancidity by the panel. In general, chemical and sensory analysis of the potato chips and of heated oils indicated no difference in the performance of the oils.

2.4 Selection of oil

Most oils used for frying are of vegetable origin, but there is no reason why animal fats cannot be used. The oil used has a great impact on the taste, texture, and keeping-quality of the final product. Fats and oils are subject to a type of deterioration known as rancidity. This produces disagreeable odours and flavours and makes the fried foods unpalatable. Some oils are more prone to rancidity than others, and this is important when considering which oil to use. In many countries, however, there is only one type of oil widely available at the lowest cost, and processors will use this, despite rancidity problems, if it gives a flavour that is acceptable.

Sakata *et al.* (1985) investigated the quality of fried foods with palm oil and suggested that it has excellent properties against oxidation, and it has been generally accepted by consumers as a vegetable oil for health foods. There is a big potential for increasing consumption of palm oil in fried foods. Severe regulation of food additives restricts the use of artificial antioxidants and therefore strict quality control is required to get stable frying oils. Consumer knowledge of foods is increasing, and our responsibility for making good quality frying fats is very important.

Agnieszka Kita and Grazyna Lisinska (2005) conducted study on the influence of oil type and frying temperatures on the texture and oil content of French fries. The material taken for the study consisted of seven types of vegetable oil: refined sunflower, rape, soy, olive oil, palm, partially hydrogenated rape oil and a blend of vegetable oils. The French fries prepared from Asterix potato variety were fried at oils heated to 150, 160, 170, 180 and 190^{0}C. The length of frying (12, 10, 8, 6.5 and 4.5 min, respectively) depended on oil temperature. Fat content and the texture of French fries were determined. The type of frying medium significantly affects the texture of French fries. Temperature influenced both the fat content and texture of product. The increase of frying temperature decreased fat uptake and hardness of French fries.

Che Man, Y. B. and. Wan Hussin, W. R (2006) studied the comparison in the frying performance of refined, bleached and deodorized palm olein (RBDPO) and refined, bleached and deodorized coconut oil (RBDCO). The oils were studied during intermittent frying of potato chips at 18^{0}Cfor 5 h/day for 5 consecutive days. Different indices were taken into consideration for assessing the frying performance of the oils. The results showed that RBDPO was superior to RBDCO in frying performance in terms of % free fatty acid, iodine value, foaming tendency and smoke point. However, RBDCO performed better than RBDPO with respect to resistance to oxidation, colour and viscosity. Flavour evaluation showed that potato chips fried in RBDPO were preferred by the panelists.

Bertr and Matthaus (2007) compared the use of palm oil for frying with other high-stability oils. They observed that it has a high oxidative stability and results in high-quality and tasty foods. They also pointed out the drawback of palm oil in comparison to conventional vegetable oils like rapeseed or soybean oil resulting from the high content of saturated fatty acids. The paper demonstrated that palm oil and its products have a similar frying performance compared to the high-oleic oils.

Fritsch *et al.* (2007) studied the stability of coconut oil in food products. The active oxygen method stability of refined coconut oil is generally 250. Refined coconut oil samples which hydrolyzed from 2 to 10 times as rapidly as normal oils have been encountered. Such samples are undesirable for food production as soapy off-flavors may be produced. The rate of hydrolysis of coconut oil samples was evaluated by a simple laboratory test. Coconut oil free fatty acids produced a soapy off-flavour at a lower level in sweet foods than in salty ones. Soapy off-flavors were produced in a low moisture food containing coconut oil by the lipase activity of cinnamon.

De Marco *et al.* (2007) compared the frying performance of a sunflower/palm oil blend with pure palm oil. They evaluated many analytical parameters like free acidity, spectrophotometric indices, fatty acid composition, tocopherol, composition, colour and flavour evaluated by means of an electronic nose etc of the selected blend during a prolonged frying process in comparison to pure palm oil. Sensory attributes of the fried food were also evaluated. The blend proved to keep qualitative parameters comparable to those shown by palm oil during the prolonged frying process. Even if some oxidation indices, such as spectrophotometric indices increased faster in the blend, it showed higher tocopherol content and a lower increment in free fatty acids as compared to pure palm oil. Chips fried in the two oils did not show significantly different sensory profiles.

2.5 Modified Atmospheric Packaging (MAP)

Modified Atmospheric Packaging is defined as "the packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air" (Hintlian and Hotchkiss, 1986). MAP is a technique used for prolonging the shelf-life period of fresh or minimally processed foods. In this preservation technique the air surrounding the food in the package is changed to another composition. This way the initial fresh state of the product may be prolonged. It is used with various types of products, where the mixture of gases in the package depends on the type of product, packaging materials and storage temperature. The initial flushed gas- mixture will be maintained inside the MA package. If the permeability (for O_2 and CO_2) of the packaging film is adapted to the product's respiration, an equilibrium modified atmosphere will establish in the package and the shelf-life of the product will increase.

The principle of MAP involves the removal of air from the pack and its replacement with a single gas or mixture of gases by either passive or active methods, depending upon the type of product.

2.5.1 Active modified atmospheric packaging

Active packaging is a group of technologies in which the package is actively involved with food products or interacts with internal atmosphere to extend shelf-life while maintaining quality and safety (Floros *et al.*1997). The potential technologies being used in active packaging are oxygen scavenging, antimicrobial packaging, ethylene control, moisture control and gas permeability control. The active MAP can be established by withdrawing air from package system with vacuumization and by back flushing with selected gas mixture. The advantages of active modification of micro atmosphere are the rapid establishment of desired gas mixtures. Adsorbents and absorbents may be included in the package system to reduce O_2, CO_2, ethylene and vapour. This kind of packaging is generally used incase of highly perishable goods like minimally processed vegetables and fruits (Labuza *et al.*1996).

2.5.2 Passive modified atmospheric packaging

The passive atmospheric packaging is also called commodity generated modified atmosphere. In this there is matching of the commodity respiratory characteristics with gas permeability of the packaging system so that a suitable equilibrium micro atmosphere can be evolved (Kader *et al.* 1988). This is through the consumption of O_2 and evolution of CO_2 in respiration process. This system of packaging can be adopted for some keepable commodities. Passive MAP mainly relies on the selective permeability of the packaging materials to different gases and on product respiration. Normally it is a slow process. The gas flush MAP involved the establishment of the specific gas composition with in the package in single stage during the packaging operation, by flushing with the selected gas mixture before sealing.

2.6 Importance of gaseous environment

Many foods spoil rapidly in air due to moisture loss or uptake, reaction with oxygen and the growth of aerobic micro-organisms i.e., bacteria and moulds. Microbial growth results in changes in texture, colour, flavour and nutritional value of the food. These changes can render food unpalatable and potentially unsafe for human consumption. Storage of foods in a modified gaseous atmosphere can maintain quality and extend product shelf life by slowing chemical and biochemical deteriorative reactions and by slowing or in some instances preventing the growth of spoilage organisms.

2.6.1 Gases used in Modified Atmosphere Packaging

The atmosphere in an MA package consists of N_2, O_2, and CO_2. It is the altered ratio of these gases that makes a difference in the prolongation of shelf life. Oxygen is essential when packaging fresh fruits and vegetables as they continue to respire after harvesting. The absence of O_2 can lead to anaerobic respiration in the package which accelerates senescence and spoilage. Too high levels of O_2 do not retard respiration significantly and it is around 12% of O_2, where the respiration rate starts to decrease. So oxygen is used in low levels (3-5%) for positive effect. In the case of vegetables and fruits, CO_2 is not a major factor since CO_2 levels above 10% are needed to suppress fungal growth significantly. Nitrogen is used as filler gas since it neither encourages nor discourages bacterial growth.

The three main gases used in modified atmosphere packaging are O_2, CO_2, and N_2. The choice of gas is very dependent upon the food product being packed. Used singly or in combination, these gases are commonly used to balance safe shelf life extension with optimal organoleptic properties of the food. Noble or inert gases such as argon are in commercial use for products such as coffee and snack products; however, the literature on their application and benefits is limited. Experimental use of carbon monoxide (CO) and sulphur dioxide (SO_2,) has also been reported.

2.6.2 Carbon dioxide

Carbon dioxide is a colourless gas with a slight pungent odour at very high concentrations. It is slightly corrosive in the presence of moisture. CO_2 dissolves readily in water (1.57 g/kg @ at 100 kPa, 20°C) to produce carbonic acid (H_2CO_3) that increases the acidity of the solution and reduces the pH. This gas is also soluble in lipids and some other organic compounds. The solubility of CO_2 increases with decreasing temperature. For this reason, the antimicrobial activity of CO_2 is marketdly greater at temperatures below 10°C than at 15°C or higher. This has significant implications for MAP of foods. The high solubility of CO_2 can result in pack collapse due the reduction of headspace volume. In some MAP applications, pack collapse is favoured, for example in flow wrapped cheese for retail sale.

2.6.3 Oxygen

Oxygen is a colourless, odourless gas that is highly reactive and supports combustion. It has a low solubility in water (0.040 g/kg at 100 kPa, 20°C). Oxygen promotes several types of deteriorative reactions in foods including fat oxidation, browning reactions and pigment oxidation. Most of the common spoilage bacteria and fungi require oxygen for growth. Therefore to increase shelf life of food, the pack atmosphere should contain a low concentration of residual oxygen. It should be noted that in some foods a low concentrations of oxygen can result in quality and safety problems (for example unfavourable colour changes in red meat pigments, senescence in fruit and vegetables, growth of food poisoning bacteria) and this must be taken into account when selecting the gaseous composition for a packaged food.

2.6.4 Nitrogen

Nitrogen is a relatively un-reactive gas with no odour, taste, or colour. It has a lower density than air, non-flammable and has a low solubility in water (0.018 g/kg at 100 kPa, 20°C) and other food constituents. Nitrogen does not support the growth of aerobic microbes and therefore inhibits the growth aerobic spoilage but does not prevent the growth of anaerobic bacteria. The low solubility of nitrogen in foods can be used to prevent pack collapse by including sufficient N_2, in the gas mix to balance the volume decrease due to CO_2, going into solution.

2.6.5 Noble gases

The noble gases are a family of elements characterised by their lack of reactivity and include helium, argon, xenon and neon. These gases are being used in a number of food applications. While from a scientific perspective, it is difficult to see how the use of noble gases would offer any preservation advantages compared with nitrogen they are being used.

2.7 Packaging films

When selecting packaging films for MAP of fruits and vegetable chips, the main characteristics to consider are gas permeability, water vapour transmission rate, mechanical properties, transparency, type of package and sealing reliability. Traditionally used packaging films like low density polyethylene (LDPE), polyvinyl chloride (PVC), polypropylene (PP), ethylene-vinyl acetate (EVA) and oriented polypropylene (OPP) are not permeable enough for highly respiring products like fresh-cut produces, mushrooms and broccoli. But this can be effectively used for packing snacks. Films designed with these properties are called permeable films.

2.7.1 Polyethylene

LDPE is heat sealable, inert, odour free and shrinks when heated. It is a good moisture barrier but is relatively permeable to oxygen and is a poor odour barrier. It is less expensive than most films and is therefore widely used for bags, for coating papers or boards and as a component in laminates. LDPE is also used for shrink or stretch wrapping. Stretch-wrapping uses thinner LDPE (25 - 38µm) than shrink-wrapping (45 - 75µm) or alternatively, linear low-density polyethylene is used at thicknesses of 17 - 24µm. The cling properties of both films are adjusted to increase adhesion between layers of the film and to reduce adhesion between adjacent packages. High-density polyethylene (HDPE) is stronger, thicker, less flexible and more brittle than LDPE and a better barrier to gases and moisture. Sacks made from HDPE have high tear and puncture resistance and have good seal strength. They are waterproof and chemically resistant and are increasingly used instead of paper or sisal sacks.

2.7.2 Polypropylene

Polypropylene is a clear glossy film with a high strength and puncture resistance. It has a moderate barrier to moisture, gases and odours, which is not affected by changes in humidity. It stretches, although less than polyethylene. It is used in similar applications to LDPE. Oriented polypropylene is a clear glossy film with good optical properties and a high tensile strength and puncture resistance. It has moderate permeability to gases and odours and a higher barrier to water vapour, which is not affected by changes in humidity. It is widely used to pack biscuits, snack foods and dried foods.

2.7.3 Aluminium films

Films are coated with other polymers or aluminium to improve their barrier properties or to impart heat sealability. For example a nitrocellulose coating on both sides of cellulose film improves the barrier to oxygen, moisture and odours, and enables the film to be heat sealed when broad seals are used. Packs made from cellulose that has a coating of vinyl acetate are tough, stretchable and permeable to air, smoke and moisture. They are used for packaging meats before smoking and cooking. A thin coating of aluminium (termed 'metallisation') produces a very good barrier to oils, gases, moisture, odours and light. This metallised film is less expensive and more flexible than plastic/aluminium foil laminates.

Krishnankutty, S (1981) conducted an experiment on packaging and storage studies of deep-fat fried nendran banana chips. Suitability of flexible packages and inert gas packing in sealed tins for storing fried. Nendran banana chips were investigated. It was found that for banana chips fried in fresh coconut oil, 300 gauge high density polyethylene and 400 gauges low density polyethylene bag packing are satisfactory up to 2 months while packing in tins under $CO_2$is satisfactory up to 6 months at room temp. (28-32^{0}C). But banana chips fried in marvo oil and packed in sealed tins under CO_2 were quite good up to 6 months whereas the chips fried in groundnut oil and packed under similar conditions were inferior in quality.

Majeed Mohammed and Lynda D. Wickham (1993) conducted an experiment on shelf life of bitter gourd through the use of reduced temperature and polyethylene wraps. They were stored individually wrapped in LDPE film or unwrapped for up to 21 days at 5–7^{o}C, 20–22^{o}C and 28–30^{o}C respectively. Assessment was done on several quality parameters including marketable quality. Storage of film-wrapped fruit at 5–7^{o}C resulted in extension of shelf-life in excess of two weeks and delayed appearance of chilling injury symptoms. Additionally, film-wrapped fruits stored at 5–7^{o}C were still marketable after 21 days, had lowest fresh weight losses, less softening, reduced incidence of post harvest rots and minimal changes in vitamin C content and pH. Storage of individually wrapped fruits at reduced temperatures therefore offers an effective method of prolonging the shelf-life of bitter gourd.

M. S. Tawfik and A. Huyghebaert (1999) described the interaction of packaging materials and vegetable oils and the stability of oil. The effects of different plastic films polyethyleneterephthalate (PET), PVC, PP and polystyrene(PS) on the stability of olive, sunflower and palm oils were studied at 24°C and 37°C during 60 days of storage. Their study indicated the major role of plastic permeability in oil stability. The rate of oxidation was not reduced by antioxidant migration from plastic films to oils. Natural antioxidant (vitamin E) retarded the oxidation rate, and this was dependent on its concentration in oils examined. The results showed that the ranking of stability of oil samples is PVC≥PET>PP≥PS. Further, the stability was dependent on the type of oil. Palm oil exhibited high stability properties while the highest oxidation rate was observed in sunflower oil. In addition, increasing storage temperature accelerated the oxidation and limited the stability of vegetable oils.

Sagar *et al.* (2000) studied the storage of dehydrated bitter gourd rings. Storage study of dehydrated bitter gourd rings packed in LDPE 200 gauge, PP 150 gauge and HDPE 200 gauge pouches were carried out for six months at room temperature and low temperature. The study revealed that the moisture and non-enzymatic browning increase with increase in storage period and increase was higher in the samples packed in 150 gauge PP followed by 200 gauge LDPE pouches. They found that the values for chlorophyll, ascorbic acid, rehydration and sensory score were better in the samples packed in 200 gauge HDPE pouch.

Susana *et al.* (2002) reviewed a modelling respiration rate of fresh fruits and vegetables for modified atmosphere packages. Respiration rate and gas exchange through the package material are the processes involved in creating a modified atmosphere inside a package that will extend shelf life of fresh fruits and vegetables. Thus, modelling respiration rate of the selected produce is crucial to the design of a successful Modified Atmosphere Packaging (MAP) system. Factors affecting the respiration rate and respiratory quotient are outlined, stressing the importance of temperature, O_2 and CO_2

concentrations, and storage time. Respiration rate models in the literature are also reviewed.

Sandhya and Singh, A.K, (2003) were carried out studies on modified atmosphere packaging of peas. The peas were packed in LDPE bags of 25 µm thickness. The shelf life of shelled peas packed in LDPE bags was 45 days, 17 days, 7 days and 4 days when stored at the temperatures of 11^0C,5^0C,15^0C and room temperature, respectively, considering the quality indices like total soluble solids, total water soluble sugars, protein, physiological weight loss and decay. The shelf life of peas was 20 days when packed in LDPE bags with 5% CO_2 and stored at the temperature of 5^oC. Statistical analysis showed that there is significant effect of temperature and storage period on total water soluble sugar, weight loss and decay of peas.

Dimitra P and Vassiliki (2004) predicted the extent of deterioration of potato chips during storage. The storage stability of potato chips removed from a continuously operated fryer at 155 to 195 °C at various time intervals was estimated by the rate of increase of peroxide value and conjugated dienes of the oil absorbed in the chips. The extent of deterioration of potato chips was correlated with the oxidation indexes of frying oil. The results showed that peroxide value and conjugated dienes increased linearly with storage time. The rates of increase were higher for higher frying temperature and longer process time, and correlated linearly with the oxidation indexes of the frying oil at the moment that the chips were removed.

Nur Dirim *et al* (2004) studied the modification of water vapour transfer rate of LDPE films for food packaging. To improve the water vapour transfer of the film, zeolite–polymer composite films and perforated films were produced. The overall evaluation indicates that the water vapour transfer rates can be modified by the composite and the perforated films which provide packaging material variety for foods of different moisture content. The available polyethylene area is reduced by the presence of solid particles and these solid particles have an important sorption property. This leads to the increasing water vapour transfer rates by the perforated films. The solid– polyethylene composite films showed less permeability to water vapour than the polyethylene film.

Roopa *et al* (2006) evaluated the effect of various packaging materials on the shelf stability of banana chips. Stability of banana chips packed in PE, PP, paper aluminium foil polyethylene laminate, PP/nylon/PP and melallised polyester and stored at 5^0C, ambient (19 to33^0C) and 37^0C were determined. Slices (2.4mm thick) of banana were fried in coconut oil for 5 minutes at 150^0C, cooled and packed. Sensory evaluation showed that banana chips stored after packing in PE and PP were acceptable up to 3 months while those in PFP, PP/nylon/PP and MP were acceptable up to 4 months stored under ambient temperature at 37^0C.

Kaliyan *et al*. (2007) conducted a study on applications of carbon dioxide in food and processing industries. Carbon dioxide as high pressure gas and supercritical fluid would find a niche in food and processing industries in the future especially in applications involving non-thermal sterilization and supercritical extraction due to its inertness, non-explosiveness, non-corrosiveness, high volatility, cooling ability, and low cost characters.

Wang *et al.* (2007) conducted a study on keeping quality of fresh-cut bitter gourd at low temperature of storage. Bitter gourd is chilling sensitive and usually cannot be stored at a low temperature for a long period. Whole and cut bitter gourds were placed in polyethylene pouches and stored at 2 or 10^0CThe results showed that the cutting enhanced the microbial growth, loss of chlorophyll starch and ascorbic acid and increased reducing sugar content, ethylene production and respiration rate of bitter gourd. The decrease of chlorophyll starch, soluble protein and ascorbic acid in the cut bitter gourd was significantly reduced. No significant indication of chilling injury in the cut or intact bitter gourd was observed during the storage for 7 days at 2^0C. These results suggested that fresh-cut bitter gourd can be stored at 2^0C to maintain its quality with high levels of ascorbic acid, chlorophyll soluble protein and microbiological safety.

Molla M. M. *et al*. (2008) found out a suitable preparation technique of quality jackfruit chips and their good packaging. Fruit's slices were treated with preservative and firming agents, pricked, blanched and then processed. Fried chips were packed in three packaging materials namely; metalex foil pouch, high density polyethylene and polypropylene pouch. A taste-testing panel for different sensory attributes using a 9-

point hedonic scale tasted the fresh and stored chips. The result of sensory analysis during the two months storage showed that the chips packed in metalex foil pouch secured the highest sensory score followed by HDPE pouch and polypropylene pouch

2.8 Subjective and objective evaluation of fried products

Farber, J.M. (1991) conducted a study on Microbiological aspects of modified-atmosphere packaging technology. This review focused on the effects of MAP on the growth and survival of food borne pathogens. The extended shelf life of many MAP products may allow extra time for these pathogens to reach dangerously high levels in a food.

Segini *et al.* (1999) studied and compared on the instrumental and sensory analysis of the texture and colour of potato chips. The instrumental measurement was a puncture test with an Intron Universal Testing Machine, and the parameters used were fracture force, deformation and stiffness. The instrumental colour quantification was a computerized video image analysis technique. Sensory evaluation of texture and colour was performed by a sensory panel. Discriminant analysis showed that tenderness and crunchiness could predict correctly 90% of the data while fracture force correlated well with all sensory attributes.

Segini, *et al.* (1999) conducted an Instron punch test with three point support of a potato chip was developed, and factors affecting the results were evaluated. Individual potato chips were fried in palm oil in a forced circulation glass container, and their moisture content and texture were determined. Sample handling parameters contributing most to variability of moisture and texture were the cutting device, and position of the sample within the tuber. For oil temperatures 140 and 180°C, and two potato specific gravities, moisture and texture changes were studied during frying. Maximum force of break was in the 2–4% moisture region.

Pedreschi *et al.* (2004) evaluated the texture of fried potatoes .The texture of fried potatoes with different shapes was evaluated after frying and in some cases after baking. He also conducted the study on blanched and unblanched potato slices at four oil temperatures: 160,170,180 and 190^{0}C until reaching a moisture content of 1.7%.The texture was evaluated using a bending test with two support points. The maximum force of deformation and maximum deformation were extracted from force versus distance curves. It was found that the unblanched potato chips were crisper than blanched chips for moisture content lower than 4%.

Misael L. Miranda and Jose M. Aguilera (2006) conducted a study on Structure and Texture Properties of Fried Potato Products. Frying imparts desirable taste and textural properties to the products, the latter described usually by the sensorial term crispness. Frying was reviewed as a structuring process and methodologies to determine texture in fried potato products. It is demonstrated that the histological and micro structural heterogeneity of potato tubers have hampered clear interpretation of experimental data and a rigorous modelling of frying. Moisture uptake during post-frying is critical in the loss of crispness (limpness) of fries and in softening of potato chips. Methods to evaluate these changes and alternatives to prolong the shelf life were discussed.

Sulaeman, A *et al.* (2006) compared the Carotenoid Content and Physicochemical and Sensory Characteristics of Carrot Chips Deep-Fried in Different Oils at Several Temperatures. Sliced carrots were steam-blanched, cooled, soaked in 0.2% sodium metabisulfite, and deep-fried in canola, palm, or partially hydrogenated soybean oil at 165, 175, or 185 °C. Frying temperature, but not oil, significantly ($P < 0.05$) affected the α-carotene, β-carotene, and total carotenoid contents. Oil type significantly ($P < 0.05$) influenced all colour values. Increasing temperature lowered the redness value, which correlated with decreased carotenoid content, colour darkening, and decreased hardness value. Trained panelists detected no differences among oil types in crispness, sweetness, odor, and acceptability. The best carrot-chip product was that fried in partially hydrogenated soybean oil at 165 °C.

Kita, A *et al.* (2007) reported the effects of oils and frying temperatures on the texture and fat content of potato crisps. The material used for the study consisted of eight kinds of vegetable oils: sunflower, rapeseed, and soybean, olive, peanut, palm, partially hydrogenated rapeseed oil (modified oil I) and a mixture of hydrogenated rapeseed oil with palm oil (modified oil II.). Potato crisps were fried in oils heated to 150, 170 and 190 °C. The measurements included: fat content of crisps determined by the Soxhlet method and texture of crisps measured using an Instron 5544. Fatty acid content of oils was determined by gas chromatography. The results of the study showed that the amount of fat absorbed by the crisps, as well as their texture, depended on the kind of oil used for frying. A relationship between oleic acid content of oil and the texture of crisps fried in refined vegetable oils was found. Fat content and texture of crisps were also influenced by frying temperatures. Crisps absorbed less fat.

Robert (2007) studied about colour and sensory characteristics of fried chips from three breadfruit cultivars and concluded that untreated chips (control) were lighter and less chromatic than the pre-dried chips because pre-drying affected sensory characteristics of fried breadfruit chips negatively.

Materials and Methods

Chapter III

MATERIALS AND METHODS

This chapter mainly deals with the Modified Atmospheric Packaging (MAP) of fried bitter gourd in different packaging materials and the methodology for determining the quality of fried bitter gourd samples.

3.1 Test sample

Preethi variety of bitter gourd (*Momordica charantia* L.) belongs to cucurbitaceae family harvested and procured from progressive farmer at Nadathara in Thrissur was used for the study.

Fresh bitter gourds were washed, topped and sliced in the form of rings of about 3mm thickness. Seeds and fibrous core were discarded. Initial moisture content was estimated using oven drying method at 70$\pm$ 1^{0}C. The moisture content was calculated using the equation (Chakravarthy, 2000)

$$\text{Moisture (\%wb)} = \frac{Ww}{W} \times 100$$

Where, Ww = weight of water, g

W = total weight of sample, g

3.2 Pre treatment

The weighed samples after mixing with correct proportion of salt and chilly powders were dried in the tray drier as shown in plate 3.1. The aluminium trays were cleaned and samples were uniformly spread with a thickness of about 3mm, since it was thin layer drying. Before keeping the tray inside the chamber, the unit was run for one hour in order to stabilize the heat inside the chamber. The air velocity was measured using an anemometer and kept constant at 1.2 m/s as air velocity does not significantly affect drying rate (Thomson *et al*.1968). By using the thermostat, temperature of 70$\pm$1^{o}C was chosen from the earlier studies (Molla *et al.*2008). Drying was done mainly for reducing the frying time.

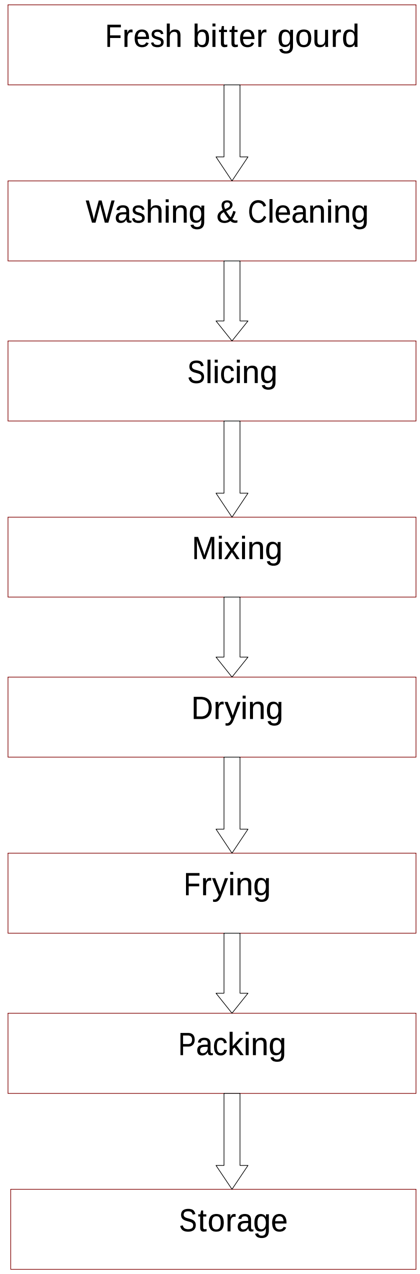

Fig 3.1 Flow diagram of the preparation and packaging of fried bitter gourd

Plate 3.1 Fresh bitter gourds

plate 3.2 Sliced samples

Plate 3.3 Tray drying

Plate 3.4 Dried samples

3.3 Frying

The dried samples having a moisture content of 6.3% were fried using coconut oil and palm oil. After the preliminary studies sample to oil ratio in coconut oil and palm oil were maintained as 1:2 and 1:1.5 respectively. The rate of water removal depends on drying time and temperature.

Plate 3.5 Fried Samples

3.4 Packaging

In order to standardize the suitable packaging material to enhance the shelf life fried bitter gourd were packed in Low-density polyethylene (LDPE 400 and 200 gauges), Polypropylene (PP 250 and 100gauges) and aluminium foil. A sample size of 100 g each was packed in the above said packages. Vacuum packaging machine with provision for MAP as shown in plate 3.2 was used for the study. In order to obtain correct proportion of nitrogen gas flushing, preliminary studies were conducted. From that 250mm Hg vacuum was found out as ideal. Treatments in the experiment are given bellow.

A- Fried bitter gourd packed in LDPE 400 gauge

B- Fried bitter gourd packed in LDPE 200 gauge

C- Fried bitter gourd packed in PP 250 gauge

D- Fried bitter gourd packed in PP 100 gauge

E- Fried bitter gourd packed in aluminium foil

Bitter gourd fried in coconut oil were denoted as A_c, B_c, C_c, D_c and E_c where as that in palm oil were denoted as A_p,B_p, C_p, D_p and E_p The packed samples were stored in ambient condition for 60 days.

Plate 3.6 Vacuum packaging machine

3.5 Gas analysis

PBI Dansensor checkmate 9900 model, portable oxygen/carbon dioxide analyzer was used for the measurement of gas concentrations with in the food packages. It consists of sample probe, which is tipped with a particulate filter and a syringe needle with side port holes to prevent plugging. In this experiment 30cc of gas is sucked from the packets and analyzed and then the different concentrations of O_2 and CO_2 are displayed on the LED display provided on the instrument. The rest of the concentration is considered as the nitrogen concentration in the sample. To sample food packs, attach the sample probe finger tight and there should not be any leakage while sampling. Pierce the food pack with the syringe needle, preferably through a foam rubber seal. Depress the pump switch and wait for the readings to stabilize. Then the reading will be displayed on the LED screen.

Plate 3.7 Gas analyser

3.6 Quality assessment of packed products

For every 20 days interval the packages were examined for the quality in terms of crispness, overall appearance, and general acceptability and also for the microbial attack

3.6.1 Objective method

3.6.1.1 Texture

The importance of texture on the overall acceptability of the foods is well known and directly affects the liking of the consumer.Texture includes those qualities that can feel with fingers, tongue, the palate or the teeth. Textural characteristics of food have both positive and negative connotations for the consumer. Texture of the product was analysed by texture analyzer as shown in plate 3.8.

It is an instrument that measures the response of a sample to a compressive or tensile force. This can be done by measuring force or by applying a force and measuring movement, both as function of time.

Plate 3.8 Texture Analyser

3.6.2 Subjective method

The Sensory evaluation of packaged bitter gourds was carried out by a panel of 10 panel judges .Different attributes that is appearance, odour, crispness, flavour and overall acceptability were observed by a 9-point hedonic rating scale.

The following 9- point hedonic scale was used for the purpose.

9- Like extremely

8-Like very much

7-Like moderately

6-Like slightly

5-Neither like nor dislike

4-Dislike slightly

3-Dislike moderately

2-Dislike very much

1-Dislike extremely

The samples were arranged in tables with specific codes. The scale was easily understood by each of the panelist and their response was converted to numerical values for computation purposes. Final results were obtained by calculating the average of all the marks given by panelist.

3.7 Microbial Analysis

3.7.1 Serial dilutions test:

This method is used for quantitative estimation of microbial cells in a known volume of original sample. In this method the organism that is present in large numbers in the mixture was isolated.

10g of the sample (fried bitter gourd porridge) was taken and dissolved in 90ml of sterile water in a 250 ml conical flask and mixed thoroughly with a shaker to give 1: 10 (10^{-1}) dilution of original sample i.e, the original sample has been diluted to 1/10th. From these solutions, 1ml (say a known weight fried bitter gourd porridge known volume of sterile water to have a suspension which contains a microbial mixture) was taken and it was added to 9 ml of sterile water which gave 1: 100 or 10^{-2} dilution of original sample. Similarly we prepared 1: 1000(10^{-3}), 1: 10,000 (10^{-4}), 1: 10, 0000 (10^{-5}) and so on dilutions of the original sample up to 10^{-8}. Media were prepared for the determination of different microorganisms like bacteria, yeast and fungus. Nutrient agar, potato dextrose and czapekdox media were used for bacteria, fungus and actinomycetes respectively. For bacteria we diluted up to 10^{-8}, for fungus up to $10^{-3,}$ and for actinomycetes up to10^{-5}. Finally one ml of required dilution (depending on the type of micro organism) was added to a sterile Petridish to which prepared 9ml of sterile, cool, molten medium was added. For each organism we prepared 3 replications for getting more accuracy. The dishes were incubated at suitable temperature. Within few days colonies of each kind of microbes grew in the dish. The number of colonies of each kind was counted. This number was then multiplied by the dilution factor to find the total number of cells per ml of the original sample.

The number of bacteria on the surface was estimated by the following formula

B = N/D

Where, B = number of bacteria
N = number of colonies counted on a plate
D = dilution factor (either 1, 10 or 100)

In a dilution,the dilution factor is equal to the ratio of final volume of solution to the initial volume of the solution.but for seriel dilution it is a product of the individual dilution factor

3.7.3 Colony Forming Unit (CFU)

In microbiology, colony-forming unit (CFU) is a measure of viable bacterial numbers. Unlike in direct microscopic counts where all cells, dead and living, are counted, CFU measures viable cells. By convenience the results are given as, colony-forming units per milliliter. The theory behind the technique of CFU establishes that a single micro organism can grow and become a colony, via binary fission. These colonies are clearly different between each other, both microscopically and microscopically. However, some microorganisms do not separate completely during the sample preparation process and the results of the count will be below the number of individual cells using direct methods.

The equipments used for the aforesaid purpose are glass wares, hot air oven, autoclave, rotary shaker, microwave oven and laminar air flow.

Results and Discussion

CHAPTER IV
RESULTS AND DISCUSSION

The present study was undertaken to standardize the effect of different packaging materials on fried bitter gourd. The fried bitter gourd were packed in different packaging materials after pretreatment and frying and stored in ambient temperature. Subjective and objective evaluations and microbial analysis of the packed products were studied.

The results obtained from different observations and analyses are discussed in this chapter.

4.1 Test samples

Preethi variety of bitter gourd (*Momordica charantia*) belongs to cucurbitaceae family harvested and procured from a progressive farmer at Nadathara in Thrissur was used for the study. The initial moisture content of 94.14% (wb) was estimated by the standard method explained in chapter III.

4.2 Pre treatment

Bitter gourd slices of about 3mm thickness were subjected to drying as per chapter III. Drying was carried till the moisture content reaches up to 6%. This is done in view to absorb less oil in subsequent frying and also for reducing frying time.

4.3 Frying

The dried samples were subjected to frying in both coconut oil and palm oil. The observed frying time was 5 minutes.

4.4 Effect of different packaging films

The fried samples were packed in LDPE (400 and 200gauges), PP (250 and 100 gauges) and aluminium foil using vacuum packaging machine by adjusting the gas flushing concentrations. The sample size in each package was taken as 100g and they were stored at ambient conditions for 60 days. For every 20 days interval the following analysis were done in order to standardize the suitable packaging material.

Plate 4.1 LDPE (400 gauge)

Plate 4.2 LDPE (200 gauge)

Plate 4.3 PP (250 gauge)

Plate 4.4 (100 gauge)

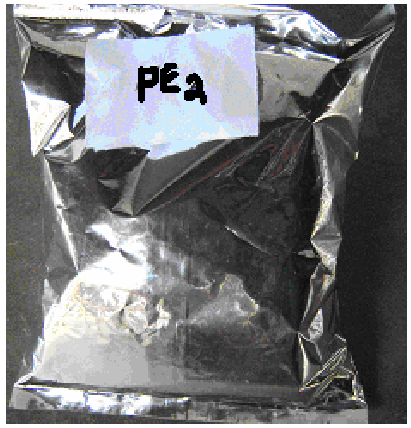

Plate 4.5Aluminium foil

4.5 Analysis of gas concentrations

PBI Dansensor (model: 9900) oxygen/carbon dioxide analyzer was used for the measurement of gas concentrations. For every 20 days interval the gas concentration of packed samples were taken.

From the table 4.1, it was noted that gas concentrations like CO_2 and N_2 decreased where as O_2 increased gradually during the storage period. This may be due to the permeability of packaging films. In plastic packaging, permeability must be taken into considerations in order to improve the shelf life of the product (John M.Krochta).

Table 4.1 Observed gas concentrations at different storage periods

Sample	0th day			20th day			40th day			60th day		
	CO_2 %	O_2 %	N_2 %	CO_2 %	O_2 %	N_2 %	CO_2 %	O_2 %	N_2 %	CO_2 %	O_2 %	N_2 %
Ac	1.4	16.6	82.0	2.1	17.9	80	0.5	19.6	79.9	0.4	20.8	79.8
Bc	3.6	15.4	81.0	2.9	18	79.1	0.6	20.4	79	0.4	21.5	78.1
Cc	2.2	15.0	82.8	1.8	17.8	80.4	0.6	19.4	80	0.6	21.6	77.8
Dc	1.7	16.4	81.9	1.2	19.0	79.8	0.5	21	78.5	0.6	21.4	78
Ec	1.7	16.0	82.3	1.2	17.6	81.2	0.6	19.3	80.1	0.4	20.9	78.7
Ap	1.4	15.1	83.5	1.4	17.1	81.5	0.7	19.9	79.4	0.5	20.7	77.8
Bp	1.0	16.6	82.4	0.4	18.1	81.5	0.5	20.8	78.7	0.5	21.8	77.7
Cp	1.4	16.0	82.6	1.1	17.2	81.7	0.8	19.8	79.4	0.3	21.7	78
Dp	0.5	16.5	83.0	0.5	19.5	80.0	0.4	20.8	78.8	0.6	21.1	78.3
Ep	2.7	15.2	83.0	1.8	16.0	82.2	1.0	18.1	80.9	0.3	20.6	79.1

From the observations, aluminium packets showed better retaining capacity than others. This is due to the thin coating on both sides of cellulose film which improves the barrier to oils, oxygen, moisture, odours and light (Raija Ahvenainen, 2000).

4.6 Quality analysis of fried bitter gourd after packaging

Quality assessments of the fried bitter gourd were done by subjective (sensory analysis) and objective methods (texture analysis).

4.6.1 Texture analysis

Texture of the different samples of fried bitter gourd packed in various packaging materials were analysed for every 20days interval and the crispness of samples were recorded. Crispness is the textural property manifested by a tendency when subjected to an applied force to yield suddenly with a characteristic sound.

The crispness/crunchiness is the important characteristic of the bitter gourd was objectively quantified by texture analyzer. From the Fig4.2 and Fig 4.3 it was observed that the various samples showed different peakness, where peakness is measures of crispness. Fried bitter gourd having good texture (crispness) showed lots of fluctuations (peaks) in force due to many fracture events The samples packed in aluminium and LDPE (400 gauge) gives maximum peakness and polypropylene (100 gauge) were gives minimum peakness and rest of them gives inter mediate results. This is because loss of crispness, due to the moisture absorption from the air.

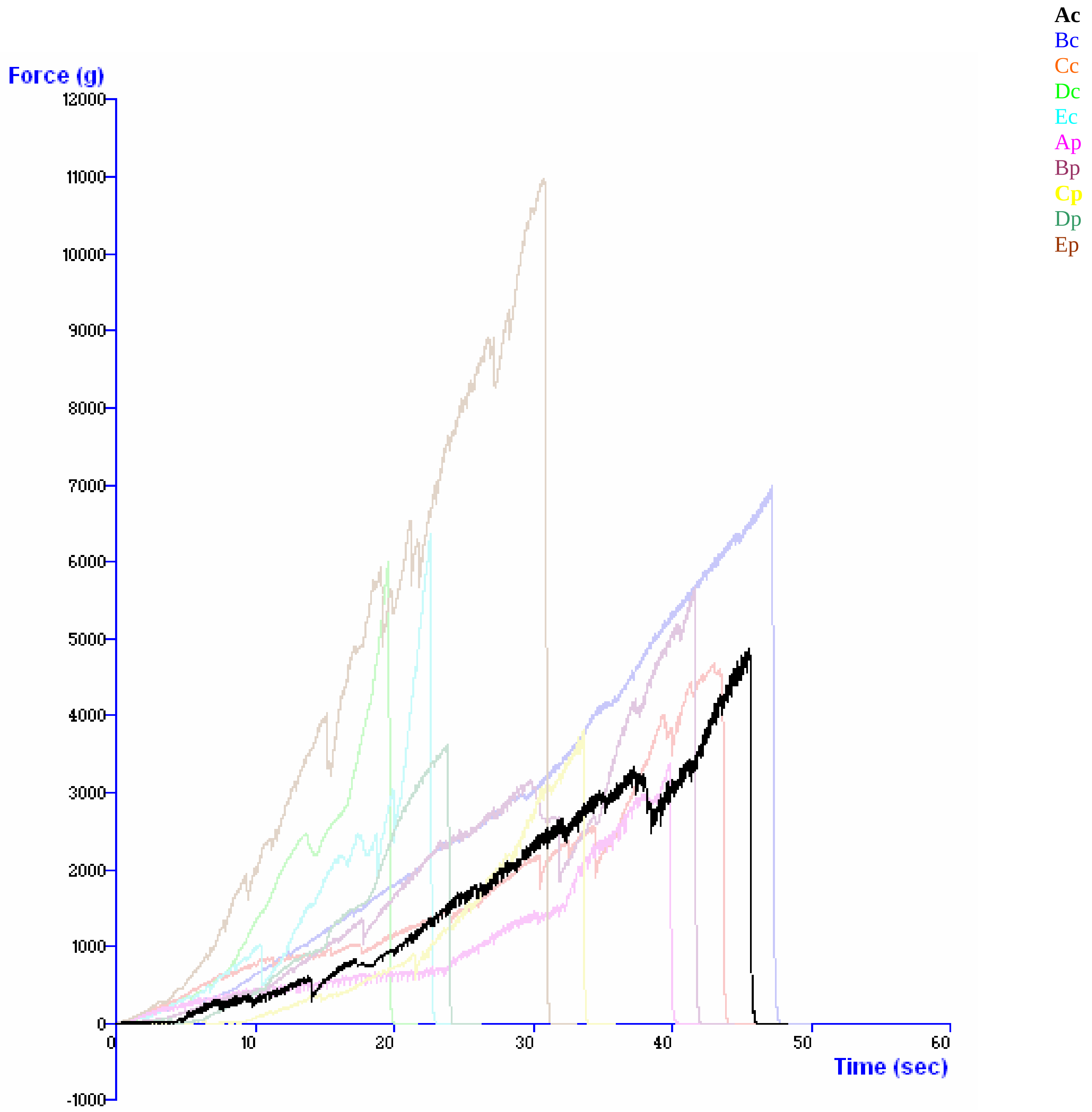

Fig. 4. 2 Force-time curve for 20th day samples from texture analyzer

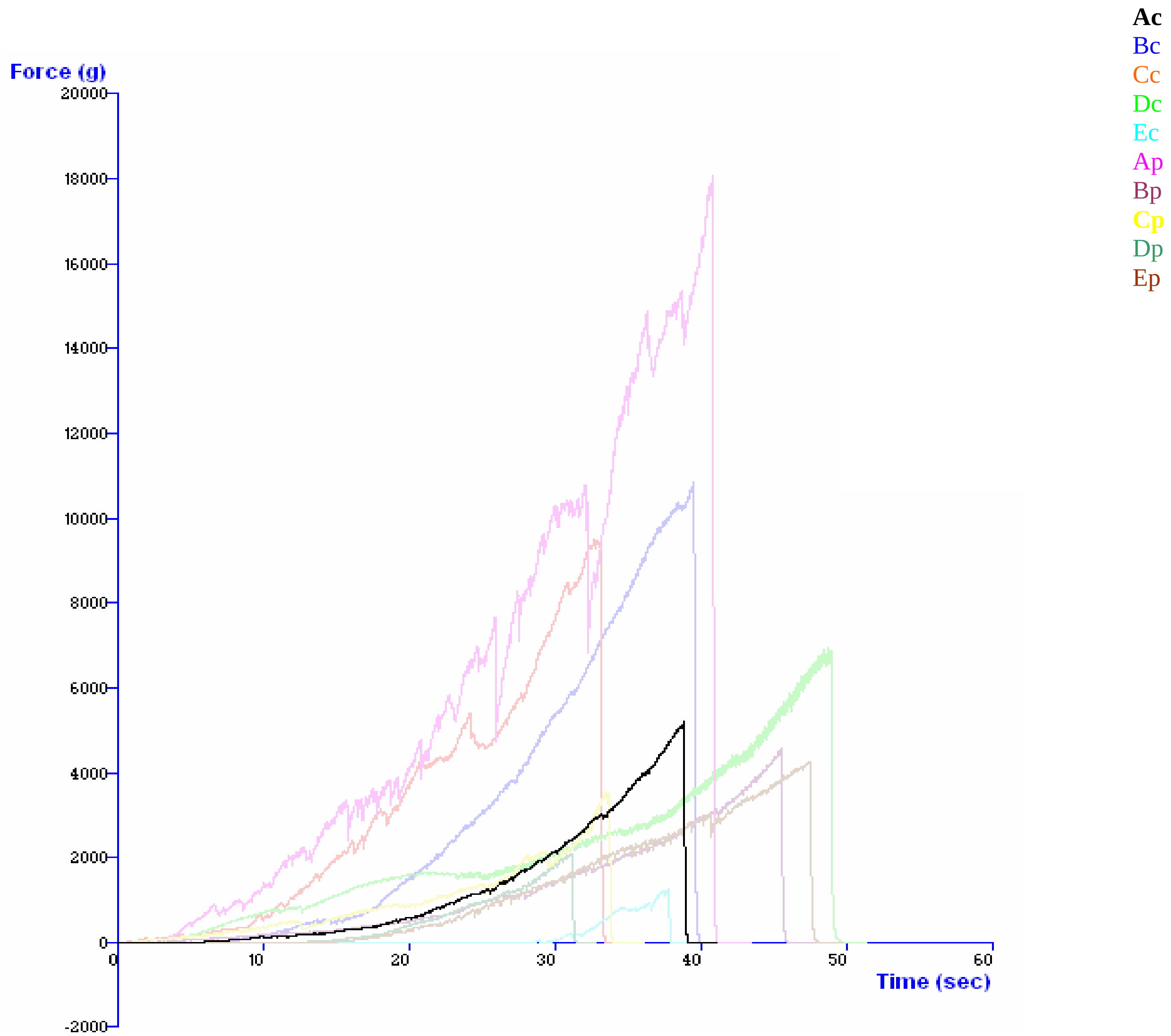

Fig.4. 3 Force-time curve for 40th day samples from texture analyzer

A- Fried bitter gourd packed in LDPE 400 gauge

B- Fried bitter gourd packed in LDPE 200 gauge

C- Fried bitter gourd packed in PP 250 gauge

D- Fried bitter gourd packed in PP 100 gauge

E- Fried bitter gourd packed in aluminium foil

Bitter gourd fried in coconut oil were denoted as A_c, B_c, C_c, D_c and E_c

Bitter gourd fried in palm oil were denoted as A_p, B_p, C_p, D_p and E_p .

4.6.2 Sensory Analysis

Sensory quality greatly influences the market performance of the product. Sensory analysis (preference test) was carried out in sensory analysis lab.10 panelists were assigned to assess the difference in the fried bitter gourd products using a 9-point hedonic scale test. Panelists evaluated parameters such as appearance, odour, crispness and flavour. These panelists assessed the quality of bitter gourd samples used in the study.

Samples	Appearance	Odour	Crispness	Flavour	Overall acceptability
Ac	7	7	8	8	8
Bc	7	6	7	7	7
Cc	7	6	8	7	7
Dc	6	7	6	7	7
Ec	8	7	8	8	8
Ap	7	8	8	8	8
Bp	7	6	7	7	7
Cp	7	6	8	7	7
Dp	6	7	6	7	7
Ep	8	7	8	8	8

Table 4.2.Mean scores of sensory evaluation

From the above table, it was observed that the fried bitter gourd packed in aluminium laminates and LDPE (400 gauge) showed the better overall acceptability than others. The samples packed in PP (250 gauge) were found to have intermediate result.

4.6.3 Microbial Analysis

Immediately after the sensory evaluation, samples were subjected to microbial analysis by the standard method explained in chapter III. In this method the microorganisms that were present in large numbers in the mixture were isolated.

From the appendix III, it was observed that microbial attacks were very negligible during the initial stage. This is because of its low moisture content. Due to the permeability nature, moisture vapour transmission takes place periodically which decreases the crispness of the product. The increase in oxygen concentration leads to the rancid odour of the fried bitter gourd. These conditions may enhance the microbial growth.

Summary and Conclusions

SUMMARY AND CONCLUSION

Bitter gourds are vegetables which contain innumerable health benefits and healing properties. In almost every portion of the world, this bitter vegetable is consumed in one form or another. Since it is highly perishable, it has to be processed. Many markets carry dried bitter gourd chips, and these chips often include regional foods and flavours to appeal to the local market. In the fast growing world consumers increasingly prefer for ready to eat products. More than those 100 grams of fried bitter gourd chips are more nutritious than 1 kg of fresh bitter gourd. In order to improve the shelf life of the fried chips, the atmosphere of the packets were modified by flushing nitrogen in desired concentration.

With this in view, an attempt was made in KCAET, Tavanur to standardize the effect of different packaging materials on fried bitter gourd. The quality of the product was expressed in terms of subjective and objective evaluation results and microbial analysis.

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

- Bitter gourds were subjected to partial drying this is done in view to absorb less oil in subsequent frying and also for reducing frying time.
- The effect of different packaging materials on fried bitter gourd were studied for 60 days and it was noted that aluminium foil, LDPE (400 gauge), and PP (200 gauge) retained the quality of the product.
- The permeability of packaging materials based on the gas concentration were studied and noted that the aluminium packets showed better retaining capacity than LDPE (400 gauge) packets.
- Bitter gourd fried in palm oil exhibited the best quality with better crispness, flavour, overall appearance and least microbial attack than that in coconut oil.

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CHAPTERVI

REFERENCE

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MODIFIED ATMOSPHERIC PACKAGING OF FRIED BITTER GOURD

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ABSTRACT OF PROJECT REPORT
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ABSTRACT

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Bitter gourds are vegetables which contain enumerable health benefits and healing properties. Due to its perishability in nature, it has to be processed to extend the storage period. Preethi variety of bitter gourd was used for the study. Bitter gourd slices of about 3 mm thickness was subjected to drying after frying and they were packed in LDPE (400 and 200 gauges), PP (250and 100 gauges) and aluminium laminates. Quality parameters in terms of crispness, overall acceptability and microbial analysis were done in every 20 days interval. The study concluded that aluminium laminates and LDPE 400 gauge were more suitable for the packaging of fried bitter gourd. The study also revealed that bitter gourds fried in palm oil showed better stability compared to that fried in coconut oil.

APPENDICES

APPENDIX I

Media compositions

Nutrient agar media

- Beef extract =0.3 g
- Peptone =5 g
- Sodium chloride =5 g
- Agar =18 g
- Distilled water =1000 ml

Potato dextrose

- Peeled potato =250 g
- Dextrose =20 g
- Agar =18 g
- Distilled water =1000 ml

Czapekdox media

- Sucrose =30 g
- Sodium nitrate =2 g
- Potassium hydrogen phosphate =1 g
- Magnesium sulphate =1 g
- Potassium chloride =0.01 g
- Agar =18 g
- Distilled water =1000 ml

Incubation temperature

- Bacteria : 28$\pm$2^{0}C for 3 days
- Fungus : 28$\pm$2^{0}C for 3 days
- Actinomycetes : Room temperature for atleast 7 days

Microbial analysis for every 20 days intervals

Sample	**0^{th} day**			**20^{th} day**			**40^{th} day**			**60^{th} day**		
	Bacteria (10^8cfu g^{-1})	Fungi (10^3 cfu g^{-1})	Yeast (10^5cfu g^{-1})	Bacteria (10^8cfu g^{-1})	Fungi (10^3 cfu g^{-1})	Yeast (10^5cfu g^{-1})	Bacteria (10^8cfu g^{-1})	Fungi (10^3 cfu g^{-1})	Yeast (10^5cfu g^{-1})	Bacteria (10^8cfu g^{-1})	Fungi (10^3 cfu g^{-1})	Yeast (10^5cfu g^{-1})
Ac	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	2	Nil	Nil
Bc	Nil	Nil	Nil	1	1	1	2	1	1	1	2	1
Cc	Nil	Nil	Nil	Nil	Nil	1	Nil	1	1	1	1	1
Dc	Nil	Nil	Nil	Nil	Nil	Nil	1	Nil	Nil	1	Nil	Nil
Ec	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Ap	Nil	Nil	Nil	Nil	Nil	Nil	2	Nil	1	1	Nil	1

APPENDIX II

Texture Analyser Setting: -

Sequence Title	:	Return to Start (Set Dist)
Test Mode	:	Compression
Pre-Test Speed	:	1.0 mm/sec
Test Speed	:	0.5 mm/sec
Post-Test Speed	:	10.0 mm/sec
Target Mode	:	Strain /distance
Strain	:	40.0 %/ 3mm
Tare Mode	:	Auto
Points per second	:	500

Texture analysis of different samples

After 20 days

Test ID	Count Peaks+ F 1:2
Ac	346
Bc	139
Cc	163
Dc	135
Ec	312
Ap	355
Bp	131
Cp	164
Dp	125
Ep	350

After 40 days

Test ID	Count Peaks+ F 1:2
Ac	330
Bc	122
Cc	146
Dc	119
Ec	306
Ap	343
Bp	126
Cp	138
Dp	99
Ep	343

APPENDIX III

Sensory evaluation after first 20 days

Samples	Appearance	Odour	Crispness	Flavour	Overall acceptability
Ac	8	8	8	6	8
Bc	6	7	6	6	6
Cc	7	7	7	6	7
Dc	5	7	5	5	5
Ec	8	8	8	6	8
Ap	8	8	8	7	8
Bp	6	7	6	6	6
Cp	4	3	4	3	4
Dp	6	7	6	6	6
Ep	8	8	8	6	8

Sensory evaluation after 40 days

Samples	Appearance	Odour	Crispness	Flavour	Overall acceptability
Ac	7	7	7	6	7
Bc	6	6	4	4	5
Cc	6	7	6	6	7
Dc	3	2	2	5	4
Ec	7	7	7	7	7
Ap	7	7	7	6	7
Bp	6	6	4	4	5
Cp	6	7	6	6	7
Dp	3	2	2	5	4
Ep	7	7	7	7	7

Sensory evaluation after 60 days

Samples	Appearance	Odour	Crispness	Flavour	Overall acceptability
Ac	5	5	5	4	5
Bc	3	3	2	3	3
Cc	4	3	4	3	4
Dc	3	3	1	2	2
Ec	6	3	5	3	5
Ap	5	5	5	4	5
Bp	3	3	2	3	3
Cp	4	3	4	3	4
Dp	3	3	1	2	2
Ep	6	3	5	3	5