INTRODUCTION
1.0 Introduction

The coconut tree (*Cocos nucifera* L.), belongs to family Arecaceae, is also known as “the tree of life” because it is one of the most important useful palms in the world and nearly all its parts have varied limitless applications in commercial world. Coconut palms are ideally suited to the humid tropical coastal climate, poor sandy soils and exposure to saline water (Child 1974). Indonesia (3.1 million hectares), Philippines (2.7 million hectares) and India (1.5 million hectares) are the top three countries that are accounting for three quarters of the total world production (in nut equivalent) of about 64 billion nuts (Mridula 2011). Coconut fruit (drupe) consisting of husk (35%), shell (28%), meat (28%) and water (15%) which is the main source of producing juice, milk and oil (Woodroof 1979). Coconut is light in weight, buoyant, highly water resistant, and can disperse via marine currents (Foale 2003). The world consumption of coconut oil, fresh coconut meat, coconut powders are 55%, 37% and 5% respectively (Anup Nair 2011). Although coconut is responsible for providing livelihood for more than ten million farm families in the country, yet productivity of coconut plantations are found to be low. Coconut is mostly a homestead crop (*i.e.* traditional agro forestry systems as base crop) in South East Asia providing income, employment, nutrition, social needs and natural beauty (Anithakumari and Lekha 2011). From the past two decades, world consumption of coconut increased from 42 million tonnes to 60 million tonnes (valued as USD 6 billion) and domestic markets itself consume around 58% of all nuts each year with a value of USD 3.8 billion. Export markets are worth approximately USD 2.3 billion. In Worldwide, many governmental bodies like, Australian Centre for International Agriculture Research (ACIAR) in Australia, Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement (CIRAD, formerly IRIIO) in France and Coconut Development Board (CDB) in India etc. are providing assistance to promote more research and development on coconut. CDB can extend support for export to international market too since it is designated as ‘Export Promotion Council’ for coconut products (other than coir and coir products) by government of India. CDB has also launched Technology Mission on Coconut (TMOC) programme and provide financial assistance to domestic and NRI entrepreneurs, cooperatives and producer companies to undertake coconut based projects.
In the present scenario, the demand of various value added coconut products such as tender coconut water, snow ball, coconut protein isolate, coconut skim milk, coconut flour and coconut oil have gained commercial interest but during recent year’s virgin coconut oil (VCO) received a lot of attention (Songkro et al. 2010). These value added products have a good international market which can strengthen coconut prices in the world. Coconut products (tender coconut oil, coconut milk, coconut milk powder or virgin coconut oil) can not be made artificially like other commercial products (rubber).

There are number of industries involved in processing, marketing, exporting value added products of coconut like ‘Pure Tropic’ exporting tender coconut water packed in tetra pack to US under the brand name ‘Tendo’. ‘Vita Coco’ for processing and marketing tender coconut water. ‘Zico’ is another company owned by US Olympic medalists, producing and marketing energy drink out of pure tender coconut water. ‘Coyo’ an Australian company makes ice cream out of coconut milk (Bose 2011). There are more than 500 companies in Sri Lanka and 1000 in Philippines which are involved in producing coconut products while in India only a couple of such companies exists (Bose 2011). Among all the value added products, coconut oil (made from copra which is dried kernel or meat of coconut) extensively used for edible and industrial (for the manufacture of chemical feed stocks, synthetic detergents, soaps and cosmetics) purpose because it is rich in medium chain fatty acids and having good digestibility (Che Man and Marina 2006).

Generally, refining process has been used to produce coconut oil and further deodorization process is carried out at high temperature or sun light resulting in the inactivation of bioactive components (e.g. tocoferols and polyphenols) (Grimwood 1975). It is also used to reduce the use of mineral oils which can cause environmental damage, as it is alternative for industrial lubricants (Jayadas 2006). On the other hand, virgin coconut oil is extracted from fresh coconut (not copra) meat by mechanical or natural means under controlled temperature. It has more nutritionally beneficial effect than copra oil because it retains most of its functional components (Marina et al. 2009b). Virgin coconut oil may have a smoky flavor and slight yellowish color. To protect the oil’s essential properties, the production of virgin coconut oil does not undergo chemical refining, bleaching or deodorizing. It is fit for consumption without any further processing. According to the standards set by Department of Trade and Industry Bureau of Product Standards of the Philippines (the world’s largest exporter of coconuts), virgin coconut oil must be colorless, sediment free with natural fresh coconut scent and free from rancid odors or tastes. It is required to have a maximum of 0.20% moisture and volatile content to prevent rancidity and should not contain food additives (Philippine National Standard/ Bureau of Food and Drugs (PNS/BAFPS) 22:2004 with amendment...
Hot, fermentation and Direct Micro expellar technique are used in the manufacture of virgin coconut oil but the most common method to produce virgin coconut oil is wet-milling method where it does not involve any direct heating or chemical reaction (Yunus et al. 2009). A process for the production of virgin coconut oil has also been patented by Raghavendra et al. (2010). Virgin coconut oil is rich in medium-chain fatty acids (MCFA) such as C:8, C:10 and C:12 having numerous health benefits. Virgin coconut oil contains lauric acid, which is considered to be very helpful in preventing infections caused by virus, protozoa and bacteria. VCO has capability to increase antioxidant enzymes and to reduce lipid peroxidation (Nevin and Rajamohan 2004). It has more antithrombotic effect over copra oil (Nevin and Rajamohan 2006). Lauric acid and its derivative, monolaurin, are both reckoned to be effective in destroying viruses such as HIV, herpes, influenza and cytomegalovirus. Virgin coconut oil stimulates metabolism and provides an immediate source of energy. Nevin and Rajamohan (2004) reported that virgin coconut oil lowered total cholesterol, triglycerides, phospholipids, very low density lipoprotein cholesterol and increased the high density lipoprotein cholesterol in serum and tissues compared to copra oil.

Generally, all chemical changes of fats and oils at elevated temperatures results in oxidation, hydrolysis, polymerisation, isomerisation or cyclisation reactions (Quiles et al. 2002; Valavanidis et al. 2004). These reactions affect the sensory, nutritional and safety properties of oil. All these reactions may be promoted by oxygen, moisture, traces of metal and free radicals (Quiles et al. 2002). Several factors, such as contact with air, temperature and length of heating, type of vessel, degree of oil unsaturation and the presence of pro-oxidants or antioxidants, affect the overall performance of oil (Andrikopoulos et al. 2002). With the rising demand of natural products and emphasis on nutritional enrichment, blending of vegetable oils and fats has emerged as economical way of modifying the physico-chemical characteristics of vegetable oils and fats besides enhancement in oxidative stability (Kochhar 2002). Most native oils and fats have limited applications in their unmodified forms, imposed by their fatty acid composition. Blending is an option to adjust fatty acid levels to optimal level like polyunsaturated with more saturated or monosaturated oil (Naghshineh et al. 2010).

Various oil cakes have been in use for feed application to poultry, fish and swine industry. Being rich in protein, some of these have also been considered ideal for food supplementation. However, with increasing emphasis on cost reduction of industrial process and value addition to agro-industrial residues, oil cakes could be ideal source of proteinaceous nutrients and as support matrix for various biotechnological applications. Several oil cakes, in particular edible oil cakes offer potential benefits when utilized as
substrate for bioprocesses. These have been utilized for fermentative production of enzymes, antibiotics, mushrooms etc. Biotechnological applications of oil cakes also include their usages for vitamins and antioxidants production (Ramachandran et al. 2007).

By using coconut oil cake (a waste produced during oil extraction) extra cellular lipase was produced from *Candida rugosa* by solid-state fermentation (SSF) (Benjamin and Pandey 1997). Mohanta et al. (2007) prepared six isonitrogenous (30% crude protein) and iso-energetic (15kJg⁻¹) diets by using different oil cake sources viz. groundnut, soybean, sunflower, sesame, mustard and mixed oil cakes. Ankrah (1998) reported that the copra generally contain 10.2% moisture, 20.6% protein, 12.6% fat, 6.0% ash and calcium and phosphorus also gave mean values of 90 and 513mg/100 gm sample. Moorthy and Viswanathan (2006) studied the effect of extracted coconut meal on egg production performance, egg quality, carcass characteristics and biochemical parameters from 21 to 52 weeks in one hundred and eighty single comb white leghorn (SCWL) layers. Dairo and Fasuyi (2008) conducted an experiment for evaluation of fermented palm kernel meal and fermented copra meal proteins as substitute for soybean meal protein in laying hen diets. Samson (2006) studied the heat treatment on coconut meat and coconut meal and reported that there was a marked loss of lysine availability upon heating coconut meats with hot air at 120°C while coconut meal can tolerate 105°C air for at least 60min without significant loss of protein solubility. Chy et al. (1983) had prepared protein isolate from defatted coconut and soybean meals. A number of value added products from coconut are available internationally but only few got consumer preference in India (Singh et al. 2007).

Though, having a lot of medicinal benefits, yet marketing of VCO is greatly hindered by the consistent message from the media all over the world that coconut oil is the one vegetable oil that should be avoided at all costs because it is a saturated fat (Etherington 2005). In developing country, the sale of coconut value added products are being made through rural shops. To enhance the widespread diffusion of coconut product in rural and urban areas, there is a need to make suitable policies from government side. There have been major failures by export marketing authorities and by research institutes, who have only focused on embodied crop technologies but not on the marketing strategies. These failures occurred amid volatile and falling prices of coconut oil on world markets and had catastrophic consequences for farmers and their families. Product diversification and attention to processing technologies, drawing on local knowledge and directed towards local demand are largely ignored. Australian involvement in coconut research is, therefore, driven by its mission to help developing countries, particularly those in the Asia pacific region. VCO is not that much popular in
commercial world because it has many weakness that need to be acknowledged like unimproved coconut palms, lack of appropriate research, less export of coconut value added products and lack of adoption of cheaper, efficient, effective environment friendly coconut processing units.

The literature survey reveals that standards for virgin coconut oil have not been laid down in India. Further, storage and thermal stability of VCO has not been studied yet. There are few literatures available on hot extracted virgin coconut oil (HEVCO) and cold extracted virgin coconut oil (CEVCO) based animal experimental studies. Not much emphasis has been given to the utilization of virgin coconut meal (VCM) for development of nutritious and healthy processed food products acceptable to the consumers. With these gaps found in literature survey, the present study is therefore planned with the following objectives:

**Objectives:**

1. To evaluate the quality attributes of virgin coconut oil (VCO) produced by hot and cold extraction processes.
2. To evaluate the shelf life of virgin coconut oil (VCO) in different packaging materials.
3. To study the stability of blended virgin coconut oil (VCO) with non-conventional oil in different packaging system.
4. To evaluate the thermal stability of virgin coconut oil (VCO).
5. Development of value added traditional Indian sweets and evaluation of their storage stability.
6. To study the effect of virgin coconut meal on different quality attributes of selected bakery products.
7. To study the effect of virgin coconut oil (VCO) on lipid profiles in hypercholesterolemic rats and modulation of diabetes in experimental animals.
Plan of Work:

1. Evaluation of different quality attributes such as antioxidant potential, total phenolic content, tocopherol and fatty acid profile in cold and hot processed virgin coconut oil (VCO).

2. Establishment of shelf life of virgin coconut oil (VCO) produced by cold and hot processes in different packaging materials such as Linear Low Density Polyethylene (LLDPE), Metallised polyester (MP), Low Density Polyethylene (LDPE), PET (Polyethylene terephthalate) bottle, High Density Polyethylene (HDPE) bottle and Amber High Density Polyethylene (AHDPE) bottle at ambient and accelerated conditions and determination of changes in quality of oil by lipid peroxidation with the measurement of lipid peroxide value (PV), free fatty acid (FFA), thiobarbituric acid (TBA) value, anisidine value (AV), moisture, color, refractive index (RI) and fatty acid profiles.

3. Blending of virgin coconut oil (VCO) to non-conventional oils such as soybean, safflower oils in different proportion and evaluation of their storage stability and quality attributes in different packaging systems under ambient conditions.

4. Studies on thermal stability of virgin coconut oil (VCO) by frying of bengal gram using continuous modes of frying and evaluation of changes in their quality attributes by measuring iodine value, refractive index, free fatty acid, peroxide value, fatty acid profile, color and polar compounds.

5. Development of a few Indian traditional sweets such as burfi and ladoo by using virgin coconut meal (VCM) and evaluation of their shelf stability in different packaging materials.

6. Studies on effect of virgin coconut meal (VCM) on various physiochemical and sensory properties of biscuits and cake using Texture Analyzer, Differential Scanning Colorimeter (DSC), Gas Chromatography (GC), Rheometer, Image Analyzer, Atomic Absorption Spectrometer (AAS) and Hunter Colorimeter.

7. Studies on effect of VCO on hypercholesterimic and diabetic Wistar albino rats by adopting two protocols after obtaining permission from IAEC (Institution Animal Ethics Committee).