1.1 Fruit Products

Fruits are important part of human diet and considered as gift of god to mankind. They are commercially important and nutritionally essential food products. Man has taken these fruits in his diet to provide variety, taste, interest, aesthetic appeal and to meet certain nutritional requirements for their body growth and development. The fruits are consumed by man, mainly because of their organoleptic and chemical property. They are plays a vital role in human nutrition, by supplying the necessary growth factors essential for maintaining the normal health. Fruits are easily digestible and contain sufficient amounts of different organic acids and digestive enzymes. Fruits are rich sources of fibres and it helps in bowel movement, prevents constipation, and an energy giving materials having high calorific value. Almost all fruits have some medicinal value. Physicians recommend fruits for the treatment of many ailments like scurvy, night blindness, asthma, fever, anemia and ulcers etc. ‘An apple a day, keeps the doctor away’ is a well known phrase indicating significance of fruits in human diet (Vidhya and Anandhi Narain, 2011).

Functional foods are more popular as the consumer recognizes that a healthy diet is more important part of life in order to control the diseases and improve the human health. The special attention is paid to fruits, as rich source of phenolic compounds (Kalt et al., 1999; Robards et al., 1999; Wang and Lin, 2000). The different fruits would exhibit different antioxidant capacity according to their polyphenol contents, vitamin C, vitamin E, carotenoids and flavonoids. The majority of antioxidant activity in fruits and vegetables is due to the presence of polyphenolic and flavonoid compounds especially anthocyanins (Bors and Saran, 1987; Bors et al., 1990; Eberhardt et al., 2000).
Fruits are important natural foods and are very good sources of several vitamins, minerals, phytochemicals, antioxidants and dietary fibres, all of which are essential for healthy life (Lamikanra, 2002). Nowadays various postharvest strategies for increasing the nutrients intake from fruits are being implemented. These include increasing consumption of fresh fruits and preserved the fruits by processed into products like jam, jelly, marmalades, candy, squash and increasing levels of essential nutrients through fortification and improving nutrients bioavailability. The different nutrients include phytochemicals and minerals contents of fruits are may be responsible for reduction of various cardiovascular diseases (Ignarro et al., 2007). Jam, jellies, fruit bars and preserves are the most important fruit products manufactured in industries based on the high solids high acid principle and prepared from a combination of two or more fruits and they possess substantial nutritive value (Vidhya and Anandhi Narain, 2011).

1.1.1 **Jam and Jellies**

Jam and jelly are intermediate moisture foods are prepared from fresh fruits by boiling fruit pulp or fruit extract with sucrose, pectin, acid and other ingredients such as chemical preservatives, coloring and flavoring substances and it is consumed as widely in the world. These products are consumed by people of all age groups and the demand is going up by year and year (Baker et al., 2005). Jam and jellies can be prepared either from an individual fruit or mixed fruits. The important constituents in the preparation of jams and jellies are pectin, sugar and acids in correct proportion for proper gel formation. The fruits were selected for jam and jelly preparation as fresh, healthy, matured and firmly ripped wherein the pectin and acid contents are good and provide better nutrients. According to the Codex standards for jam and jellies, the total
solids content should be between 60 - 65% for jam and 40 - 65% for jelly (CODEX, 2009).

Fruits are major food products and considered as key ingredients in many processed food. Having fruits in daily diets has long been associated with health benefits. A number of studies have supported the association between a high consumption of fruits and low incidences of certain chronic diseases (Vant et al., 2000; Lir et al., 2000). Therefore, there is a considerable demand for fresh fruits as well as their products. Most of the fruits are available only in particular season and their shelf life is limited; this requires some processing to preserve the nature of the fruits and to maintain its quality attributes (Scibisz and Mitek, 2007). Jams and jellies were originated as an early effort to preserve the fruit for consumption in the off-season (Baker et al., 2005). Jam and jellies had considerable nutritional value, with high levels of vitamin C, phenolic compounds, carotenoids and antioxidant activity. Therefore, it is a good food alternative and its consumption are value addition to fruits as well as to its cultivation.

Jam and jellies are fruit based products had considerable nutritional value with desired level of vitamin C, phenolic compounds, antioxidant activities and other nutrients has been reported by Rababah et al. (2011) and Amakura et al. (2000) and Wicklund et al. (2005). Fruits and fruit based products are good source of minerals such as potassium, magnesium, phosphorus, calcium, iron and it is essential for the human body growth and development (Worthington, 2001). Mixed fruit jams and jellies are prepared from combination of different fruit pulps which are good source of carbohydrates, vitamins, minerals, pectin, dietary fibers and high energy value that are essential components for normal growth and development (Vidhya and Anandhi Narain, 2011).
1.2 Preservation of Fruit Products

The consumption of fresh fruits, vegetables and its related food products has increased over the past two decades for many reasons; consumers are more concerned about eating as nutritive food and being healthy and in response to this, the demand of fresh fruits and vegetable products has increased. However, increase the chances of outbreaks of food poisoning and food infections related to consumption of fresh fruits and vegetable products (Warriner et al., 2009). Normal microflora of fruits is diverse and includes variety of moulds *Rhizopus, Aspergillus, Penicillium, Eurotium, Wallemia* and the yeasts *Saccharomyces, Zygosaccharomyces, Hanseniaspora, Candida, Debaryomyces* and *Pichia* sp. and bacteria such as *Pseudomonas, Erwinia, Enterobacter* and *Lactobacillus* sp. which are predominant in fruit products. These microbes attached to outer skin of fruits and it comes from several sources such as air, soil, compost and insect infestation and which are resistant to most of the postharvest processing of fruits (Pao and Petracek, 1997).

Fruits and its products are having more acidic pH and it favoring the growth of yeasts and moulds which are more acid-tolerant than bacteria. The common moulds to be involved in fruit spoilage such as *Penicillum* sp., *Aspergillus* sp., *Eurotium* sp., *Alternaria* sp., *Cladosporium* sp. and *Botrytis cinerea* and some moulds are producing heat-resistant ascospores such as *Paecilomyces fulvus, P. niveus, Aspergillus fischeri, Penicillum vermiculatum* and *P. dangeardii* were reported to cause spoilage of thermally processed fruit products and its affecting the shelf life of the product by production of off-flavors, visible mould growth, starch and pectin solubilization and loss of product texture (Beuchat and Pitt, 1992; Splittstoesser, 1991). The processed fruit products such as fruit concentrates, jellies, jams, preserves and syrups have some normal microflora may include osmophilic yeasts and moulds and certain endospore-
forming bacteria such as *Clostridium*, *Bacillus* sp. that withstand the canning procedures. These are increases the chances of spoilage of fruit products and foodborne infections related to consumption of these types of food products (Lund and Snowdon, 2000).

Jams and jellies are sugar containing food products which are possible to getting microbial spoilage immediately after preparation. The shelf life of traditional jam and jelly products have minimum storage period when without use of any preservation method (Waseem Tahir, 2002). The moulds and bacteria are major sources of spoilage of fruit products and their presence in the finished products beyond the permissible level is considered unfit for consumption (Vidhya and Anandhi Narain, 2011). The presence of moulds in food may result in reduction of food quality and also contamination of food with mycotoxins, which are causing major health problems (Calado *et al*., 2014). In the past few decades, increased number of major foodborne disease outbreaks and many deaths attributed to consumption of fresh, precut and minimally processed fruit products has been reported in several countries (Beuchat, 1996; Viswanathan and Kaur, 2001; Calado *et al*., 2014).

### 1.2.1 Chemical Preservatives

Processed foods contain many chemicals that are added to preserve the food by extending the shelf life and to prevent spoilage. Benzoic acid in the form of its sodium salts are used widely for the preservation of jams and jellies. Other chemical preservatives such as potassium metabisulphite, sorbic acid, calcium propionate and sodium benzoate are also used as preservatives in most of the food products. But, many spoilage causing bacteria and some moulds and yeasts are more resistant to these types of chemical preservatives. Therefore, benzoic acid and its related chemical preservatives are cannot completely eliminate the microorganisms and less effective in
preservation of food products, in particular fruit spread, preserves, jam, marmalades and jellies (Baird-Parker, 1980). Chemical preservatives are fairly specific in their action against microorganisms and there is no chemical preservative that is completely effective against all microorganisms present in food products (Lueck, 1980 and Waseem Tahir, 2002). Falco et al. (1993) studied the effect of sodium benzoate and potassium sorbate on *Penicillium italicum* and *Aspergillus ochraceus* and reported that *A. ochraceus* was significantly more resistant than *Penicillium italicum* to sodium benzoate and potassium sorbate. In addition, chemical preservatives in food products give undesirable changes in flavor, colour and nutrients of food products (Diehl, 2002). When chemical preservatives are mixed with ascorbic acid, present in the herbal products, it produces benzene, a carcinogenic compound (Ellis-Christenson, 2000; Harvey, 1917; Ramathilaga and Murugesan, 2011). The food additives such as chemical preservatives and artificial colours added jam and jelly products were used more in the diet of young children’s results in increased hyperactivity and other health related problems (McCann et al., 2007). The children’s are more susceptible than adults to chemicals added food items and their exposure and consumptions are often higher than those of adults (Goldman and Koduru, 2000). The benzoates are widely used in foods and it is responsible for asthma, allergic rhinitis, flushing in some peoples and chronic urticaria. The sorbates are added to foods and act as antimicrobial agents rarely it causes urticaria and contact dermatitis are reported. These types of chemical preservatives are harmful when consumed for long time (Kinderlerer and Hatton, 1990). Irradiation of food products has the advantage in food packaging and less person to food contact in preparation thus reducing the possibility of contamination and reducing the use of chemical preservatives, some of which may be harmful to human health (John, 2003).
Most of the countries have stricter rules to governing the additives permitted in their food supply. There are several consumer organizations questioning the safety and long-term health effects of the chemicals used in foods. Many health practitioners, nutritionists, naturalists and other health minded consumers avoid preservatives and other chemical additives. Most of the common chemical preservatives used for decontamination of microorganisms are banned worldwide. And also they are leave toxic residues, which is hazardous to human health and environment (Rajeev et al., 2008). Therefore, it increases the demands for safer and healthier processed foods and it drives the development of new technologies in food processing sectors to obtain good quality products.

1.2.2 Food Irradiation

Food safety is one of the major challenging issues today, although many preservation processes and regulations are already available to control the microbiological and chemical integrity of food. Food irradiation is one of the most important technologies that contribute to improve the safety of food. Food irradiation is a physical method of food processing that involves exposing prepackaged and bulk foodstuffs to ionizing energy and the inactivation of microorganisms is achieved at low temperatures. Using irradiation, the microbiological safety of food can be improved and its shelf-life prolonged without changing the nature of the products. Irradiation process improves the shelf life and nutritional quality of fruits, vegetables and their products by destructing the micro flora and provides a suitable alternative to chemical treatments (Thayer and Rajkowski, 1999). Treatment of food products by ionizing irradiation is a well known decontamination method (Frakas, 1998).
Electron beam irradiation has a short processing time, does not produce radioactive waste and it destroys the major pathogenic food borne bacteria (Rodriguez et al., 2006). In previous studies reported, the electron beam irradiation could be considered as effective method to improve the microbial quality and increase the shelf life of many food products include wild chamomile (Nemtanu et al., 2008), Spirulina (Brasoveanu et al., 2005), soy beans (Wilson et al., 2007) and Mucuna pruriens seeds (Bhat and Sridhar, 2008). Living cells are inactivated when exposed to ionizing irradiation that substantially changes their cellular structure and physiological functions. The damages include DNA strand breakage, cell membrane rupture and mechanical damage to cell walls (Lado and Yousef, 2002). Therefore, using irradiation microorganisms, insect gametes and plant meristems are prevented from reproduction (Farkas, 2006).

This research is focused on the application of irradiation technology targeted to preservation of fruit products, instead of use of chemical preservatives. Application of irradiation is a relatively an innovative technology to enhance food safety, quality and trade of food products. Mixed fruit jam and jellies products were selected for preservation by employing electron beam irradiation. Thus the aim of this study was to evaluate the effect of electron beam irradiation on proximate, antioxidant, minerals, sensorial and microbiological properties of jam and jelly products.
1.3 Objectives

- To prepare the mixed fruit jam and jelly products by without any chemical preservatives
- To irradiate the freshly prepared mixed fruit jam and jelly products with using various doses of electron beam irradiation
- To analyze the proximate changes of jam and jelly products after irradiation
- To study the antioxidant activity of jam and jelly products after irradiation
- To determine the minerals content of jam and jelly products after irradiation
- To evaluate the sensorial properties of jam and jelly products after irradiation
- To enumerate the microbial load after irradiation with various doses and durations
- To determine the shelf life and optimize the irradiation dose for jam and jelly products
- To assess the suitability of the irradiated products for human consumption