CHAPTER 1

INTRODUCTION

Plant-based food materials are very essential in supplying nutrition and maintaining the health and wellness of human beings. They are considered as the suppliers of important sources of vitamins, minerals, flavour to human diet. Their varied aroma and structure make the diet more appetizing and palatable with pleasing taste. It is widely known that many of the fruits are rich sources of vitamin C and contain carotene which could be converted into vitamin A by our body. The nutritional value of the fruits and vegetables in human diet is comprehended by the dietary fibre which is comprises of cellulososes, hemicelluloses, pectic substances and lignin.

Plant-based food materials, especially, the fruits and vegetables constitute about 80 percent of humidity which forces them to be highly perishable in nature. Because of this high moisture level, they cannot be stored at ordinary conditions for a long period which leads to heavy losses of the product. The developing countries pose a severe problem of raw produce losses to an extent of 30 percent because of many reasons, including poor handing, insufficient cold storage facilities and transportation apart from the water loss and decay losses (Jayaraman & Gupta 2006, Kaya et al. 2007). This could lead to severe quality losses in the food materials by degrading the availability of essential nutrients, vitamins and minerals and also deteriorates the value of the product, thereby incurring economic losses.
Owing to the advent of developments in agricultural technologies the production of fruits and vegetables around the world are escalating considerably. The countries like China, India, Italy, Brazil, Mexico, Spain, Iran, Philippines, Indonesia, France and Turkey are the foremost fruit producers in the world. India is blessed with a wide range of physiogeographical and climatic conditions. This suits the cultivation of different varieties of plants and trees which could yield various types of food materials. The production through the cultivation of horticulture crops in our country has increased by 30 percent in the last five years as per the statistics. This has placed India among the foremost countries in horticulture production next to China. It is reported that during the year 2012-13, India’s contribution in the world production of fruits and vegetables was 12.6 percent and 14 percent respectively. The total fruit production during 2012-13 was 81.2 million tonnes while that of vegetables was 162 million tonnes and will increase during the subsequent years.

Since the fruits and vegetables are highly perishable commodity, spoilage of them occurs in larger quantities. They are forced to sell at much cheaper rates at the time of glut period and cultivators become the victims of severe monetary losses. Hence, enhancing the shelf life of these fruits and vegetables not only prevents the wastage but also makes it available even during off season at reasonable price (Singh et al. 2007). Among the various fruits and vegetables cultivated in the country, banana, amla, ash gourd and bitter gourd are the most accepted fruits and vegetable in the South east Asia because of their economic importance and nutritive value. They are used for the preparation of different varieties of culinary food materials because of their numerous biological activities (Sathishsekar & Subramanian 2005, Budrat & Shotipruk 2008).
“Banana” is a common term for several species or hybrids in the genus Musa of family Musaceae. Banana and plantain (Musa spp.) are considered to be the stable food for millions of people in many countries. Banana has considerable amount of health benefiting impediments such as minerals, anti-oxidants, vitamins, soluble dietary fiber, vitamin-B6 (pyridoxine) and moderate quantity of about 8.7 mg per 100g vitamin-C. The flesh of the fruit is easily digestible and is made up of simple sugars (sucrose and fructose) that replenishes energy instantly upon consumption and rejuvenates the human system. The production of banana in the world has increased and it is estimated to be 80.6 Mt in the year 2016. Though the supply of banana is quite abundant, but at the same time, its loss can reach 40 percent mainly due to lack of insufficient warehouse, cold storage facilities and industrial processing during peak harvest season.

Amla (Emblica officinalis L.) commonly known as Indian gooseberry, is a notable seasonal fruit crop belonging to the Indian sub-continent (Suresh Kumar & Sagar 2009). It is highly nutritious and is a good resource of ascorbic acid (Vitamin C), amino acids and minerals. It contains ascorbic acid (500-1500 mg per 100 g of pulp) (Chauhan et al. 2005). The medicinal properties of amla were recognized as a preventive and therapeutic drug for cancer in humans (Bhandari & Kamdoa 2012). Amla is highly perishable in nature and it can be stored under atmospheric conditions only for about 5 to 6 days after harvesting (Pathak et al.. 2009). The shelf life of the fruits can be increased by adopting appropriate processing methods and it could eliminate the losses to a tune of 30% (Goyal et al. 2008).

Bitter gourd (Momordica charantia) which belongs to ‘Cucurbitaceae’ family is one of the most popular vegetables in the Asian subcontinent and has great economic importance. It is popular due to its bitter
properties with high nutritive value and is unique due to culinary and medicinal purposes. The presence of momordicines is responsible for the bitter taste in bitter gourd. Though this vegetable is having bitter taste, it is valued for its medicinal properties, particularly for the treatment of general fevers, malaria and diabetes (Kedar & Chakraborti 1982). It is also considered to be a good source of dietary fibers (Gopalan et al. 2000). Bitter gourd contains a collection of active plant chemicals which includes triterpenes, steroids, proteins and rich source of vitamin B, folic acid, phosphorus, magnesium, zinc and manganese and high nutritional fiber. It is used for the preparation of different culinary food materials due to its biological activities such as antibiotic, antibacterial, antidiabetic, anti-ulcer, antioxidant, antiviral, antimycobacterial, antimicrobial, etc. (Sree Jayan & Rao 1991, Sathishsekhar & Subramanian 2005, Budrat & Shotipruk 2008). These medicinal and special culinary benefits of bitter gourd create good demand during off season; it has necessitated preserving this vegetable in order to enhance its shelf life and availability by producing value-added products.

In Southeast Asia, Ash gourd (*Benincasa hispida*) is considered as one of the most popular vegetables. The major fraction of ash gourd is moisture and it also contains petite quantities of protein, carbohydrates, fat and fibre, minimal amount of phosphorous, calcium, iron, riboflavin, thiamine, niacin and Vitamin C (Randhawa et al. 1983). It is also reported that the ash gourd contains low level of sodium and high level of potassium with low calorific value along with many amino acids (Gopalan et al. 2004). It has numerous medicinal values and can be used as diet food for diabetics, curing peptic ulcer and acts as blood coagulant. The vegetable is regarded for the preparation of various food materials of culinary nature and for making variety of products by value addition. Because of its high moisture content and perishability, a large quantity of the produce is spoiled and renders
financial loss to the producer. Hence, preservation of this vegetable by adopting suitable preservation technique has become necessary for the prevention of huge spoilage and for their availability during the off-season thereby providing remunerative price to the cultivator and the processor.

The presence of water content in the fruits and vegetables leads to processing the food materials at the earliest. This will minimize the post harvest losses due to spoilage during the glut period. Diversified techniques to facilitate the processing operations can be adopted to preserve the fruits and vegetables. Among all the preservation methods, the water removal from plant based food materials by drying and dehydration processes is one of the known conventional methods to preserve the foods and recognized as the most promising operation practised by mankind.

The conversion of fresh fruits and vegetables into value added products by drying process has many advantages such as, increase in market value, saving in packaging, storage, consumer convenience and extension of shelf life of the material. The dried product possess an extended shelf life due to the reduction in moisture level of the raw material which could restrict the physico-chemical and microbial deteriorations. Generally, the consumers expect that the dried products should have the properties almost close and similar to that of the fresh produce. Commercial scale production of dried fruits and vegetables has gained momentum during the recent years and has become a significant division of the processing industry. Good quality dried products from fruits and vegetables can be obtained by the use of various drying techniques and hence the post-harvest losses that occur in developing countries can be minimized which will improve the nation’s economy and provide monetary benefit to the producer (Karim & Hawlader 2005).
The preservation and drying behaviour of fruits and vegetables are highly influenced by their morphological characteristic features. Water is one of the major components and occupies an important role in influencing the quality and stability of the products. Among the various drying methods, convective drying method is widely practised in the food industry because of its simplicity, inexpensive in operation, simultaneous heat and mass transfer process and also with a change of phase occurring during the process (Barbanti et al. 1994). This technique utilizes the flow of hot air stream that heats the fresh food product and water content present in it is removed. The drying time required for the removal of moisture will vary depending upon the nature and type of the food product. During drying process, the food materials are exposed to high temperature and contact with oxygen in the air which may reduce the quantity of some of the valuable constituents and affect the physical quality of the food product. The disadvantages rendered by the convective air drying methods can be eliminated by adopting suitable pretreatment techniques which will enhance the quality of the final product.

Osmotic dehydration process is recognized as one of the promising pre-treatment techniques and has received considerable attention now-a-days. This method can be conveniently coupled with the further drying methods as it reduces the initial water content which subsequently shortens the total processing time, energy consumption reduction and food quality enhancement (Jayaraman & DasGupta 1992, Torreggiani 1993, Karathanos et al. 1995). Apart from these advantages, the process also retains natural colour, volatile aromas and inhibits enzymatic browning during the ensuing air drying process (Pokharkar et al. 1998). Osmotic dehydration process is basically a non-thermal process where the dehydration from the sample occurs through impregnation process and it has the ability of minimizing the negative changes of fresh food constituents due to the pressure difference...
between hypertonic and hypotonic materials. In this process, water from the hypotonic material is leached out and solute is transferred from hypertonic solution to hypotonic material (Rastogi et al. 2002, Shi et al. 2009).

The process of osmotic dehydration has the potential to remove a considerable amount of water by direct contact or immersion of a moist food material in a solution of high concentration (hypertonic medium). The solute used for the preparation of the solution may be sugar or salt. The concentration difference between the intracellular fluid of hypotonic material and highly concentrated medium leads to remove the moisture due to the motivating force of hypertonic solution. Usually, during the early period of osmotic dehydration process, the rate of mass transfer will be higher because of the osmotic pressure difference between osmotic solution and food material (Moreira & Sereno 2003). The rate of water removal and alteration in the chemical compounds of the food material depend on the nature and concentration of solute used in osmotic dehydration process, temperature at which the solution is kept, duration of immersion, fruit to solution ratio, material size and variety of material, agitation and the type of apparatus used.

During the process of osmotic dehydration, two major countercurrent flux take place. The first flux is water loss which occurs due to the leaching of water from the sample towards osmotic solution. The second major flux is the diffusion of osmotic solutes into the sample and this is called as solid gain. These two fluxes are opposite in direction and occur simultaneously. Other than these two fluxes, the third flux is the loss of other compounds (organic acids, vitamins, saccharides and minerals) which flow from immersed sample into the osmotic solution. Though this type of flow has very less amount in terms of mass exchange, it will affect the organoleptic properties and final nutritive values of food (Khin et al. 2006). The
relationship between water loss to solid gain determines the effectiveness of osmotic treatment considering that the moisture removal must be greater than the solid intake (Ravindra & Chattopadhyay 2000, Chenlo et al. 2007).

The main component of the osmotic dehydration process is osmotic solution which is prepared with solvent (usually water) and one or more solutes. There are many osmotic solutes used for the preparation of osmotic solution. The type and character of osmotic agent decides its capability for reducing the activity of water and affects the driving force that is required for water removal and solid uptake. If solutes of higher molecular weight are used, it will reflect in decreased solid gain and increased water loss which obviously favours weight loss and dehydration (Prakash et al. 2004).

For fruits, sugar is the commonly used solute. The other solutes which are used as osmotic agents include glucose, fructose, maltodextrine and corn syrup (Ispir & Togrul 2009). Common salt (sodium chloride) is the most used solute for vegetables. In some cases, a combination of solutes can also be used. Some of the advantages of osmotic process are minimized heat damage, least discoloration of fruits by enzymatic browning, increased retention of volatile, flavours and aroma, improved textural quality and lower energy consumption than the air drying. The osmotic dehydration process will not yield a shelf-stable final product of sufficiently low moisture content. Hence the osmotically dehydrated product has to be further dried by means of other air drying methods (Lenart & Lewicki 1998).

Osmotic dehydration process is considered as a pre-drying step and is combined with other methods of drying. One of the combinations is ‘osmo-convective drying’ where osmotic dehydration process is followed by convective drying and many investigations have been conducted by several researchers (Kar & Gupta 2003, Murumkar et al. 2007, Shukla & Singh 2007,
Vishal et al. 2009, Dehkordi 2010, Jain et al. 2011, Pisalkar et al. 2011). The prime objective of this method of drying is to create favourable conditions for longer storage without any deterioration, reduce the packaging necessities and weight of final products.

Through the process of osmo-convective drying, the food products attain improvements in quality as compared to the materials dried under uncontrolled methods of drying like sun and direct-heated air drying. The reason for the poor quality of the end product dried under uncontrolled drying conditions is due to the irregular temperature control and exposure of the material to high temperature for a prolonged time. The texture of the products is also affected due to the continual deduction of moisture from higher to lower. The pore spaces are blocked by osmotic solutes during osmotic dehydration process and hence cause hindrances in absorption of water during rehydration process. Therefore, the dry weight, rehydration characteristics, nutritive elements, colour, organoleptic quality, texture and storage life of dehydrated fruits and vegetables are improved to a great extent through osmo-convective drying (Ponting et al. 1966, Rault et al. 1989, Ertekin & Cakaloz 1996). The transportation cost is also reduced and comparatively higher price is obtained for the value added product in the consumers’ market. It is also reported that there is considerable savings in energy in osmo-convective drying, as compared to conventional process which has to be scientifically evaluated further (Islam & Flink 1982).

Combination of osmotic dehydration and convective drying process is one of the capable methods to dry the plant-based food materials through reasonable energy consumption, enhanced shelf-life and good quality. This technique is particularly advantageous since considerable portion of moisture is removed by non-thermal method with the simultaneous infusion of
desirable solutes. After completion of osmotic dehydration, thermal drying process is needed to bring down the moisture content to a final value. So far no systematic and organized research work has been reported to study the drying characteristics of osmotically pre-treated amla, banana, ash gourd and bitter gourd. Hence, in the current research work, an effort has been taken for investigation and optimization of the pretreatment process (osmotic dehydration) and further drying at different drying condition (temperature and air velocity) in order to produce shelf-stable products from amla, banana, ash gourd and bitter gourd. A detailed study on literature review was done to examine the current research works carried out globally and a brief report is presented in the following chapter.