CHAPTER I

INTRODUCTION

Onion (*Allium cepa*), one of the main crops under Allium family has been cultivated mainly in the tropical countries since long time. Besides imparting a characteristic taste and flavour to food it also has significant therapeutic values (Augusti, 1996; Dron et al., 1997). Onion serves as a good medicinal compound for cataract, cardiovascular disease and cancer due to its hypocholesterolemic, thrombolitic and antioxidant effects (Block, 1985; Block et al., 1997; Nuutila et al., 2003 and Stavric, 1997). Onion also contains a variety of other naturally occurring organosulfur compounds that helps in lowering blood pressure and cholesterol levels. Several antioxidant compounds, mainly polyphenols such as flavonoids and sulfur-containing compounds have been described in onion and garlic (Banerjee et al., 2002; Block et al., 1997; Gorinstein et al., 2005; Horie et al., 1992; Kourounakis and Rekka, 1991; Ly et al., 2005; Nuutila et al., 2003; Prasad et al., 1995; Suh et al., 1999 and Yamasaki et al., 1994).

The gradually increasing production status of onion itself speaks of its high demand. At least 175 countries grow onions. The world production of onion was 64.48 million tonnes in 2007 from 3.45 million hectare area (FAO, 2009). National Horticultural Research and Development Foundation (NHRDF) estimated that during the year 2007, China ranked first in area and production with 20.55 million tonnes of onion from 1 million hectare and India stood second with 8.18 million tonnes from 0.619 million hectare of land. However, the productivity of onion is highest in Ireland (58 tonnes/ha), followed by Korea Republic (57 tonnes/ha), USA (55.88 tonnes/ha), Spain (52 tonnes/ha), Chile (48.50 tonnes/ha), Australia (49 tonnes/ha) while India has a productivity of 13.20 tonnes/ha (NHRDF, 2009).

Approximately 8 percent of global onion production is traded internationally. In the year 2009-2010 India exported 1.125 million tonnes of onion. It is a crop of national importance and considerable attention has been paid by the National Agricultural Research System of the country to the improvement of this crop. NHRDF sponsored by the apex level cooperative called the National Agricultural Cooperative Marketing Federation of India (NAFED), and the National Research Center on Onion and Garlic of the Indian Council of Agricultural Research (ICAR) are engaged in systematic efforts for the improvement of onion.

India produces three varieties of onion viz. red, yellow and white. The production as well as market value of this potential vegetable is increasing day by day. Table 1.1 shows the yearly increase in area and yield of onion production in India.

Table 1.1: Yearwise Status of Area, Production and Yield of Onion in India

Year	Area (million hectare)	Production (million tonnes)	Yield (tonnes/ hectare)
2001-2002	0.45	4.83	10.69
2002-2003	0.42	4.21	9.91
2003-2004	0.50	5.92	11.78
2004-2005	0.55	6.43	11.72
2005-2006	0.66	8.68	13.12
2006-2007	0.62	8.18	13.20

(Source: FAO, 2009).

The area under onion rose by 10.3% in 2008 from the preceding year mainly due to rise in acreage in Maharashtra, Gujarat and Madhya Pradesh. Other important onion growing states are Karnataka, Orissa, Uttar Pradesh, Andhra Pradesh, Rajasthan, Tamil Nadu and Bihar. Onion grows both in the rabi season and kharif season. Out of the total fresh vegetable exports, onion contributes a substantial share of 67%. NHRDF has developed 3 types of onions – Agrifound Dark Red and Agrifound Light Red (big onion), Agrifound Rose (small onion) and Agrifound Red (multiplier onion) for export. Onion, a major ingredient in Indian food, and a politically sensitive commodity, is typically cultivated thrice a year – in monsoon, winter and summer. According to 'Directorate of Economics and Statistics, New Delhi', the production of onion in 2008-2009 year was 7.37 million tonnes from 0.53 million ha area (NHRDF, 2009).

Among fresh vegetables, onion, tomato and mushroom are reported to be highly export competitive (Kumar, 1996; Paroda, 1999). Singh et al. (2006) reported that onion has 6% share in the overall production of vegetables in India. However, in fresh form it can not be stored for a long period (Shukla and Gupta**,** 1994). Post harvest losses in onion varying in the range of 20-50% are reported (Lawande, 2004). Proper processing and storage of onion is therefore necessary.

Onions are mainly processed by dehydration as it is the most convenient and utile way to preserve and use. Dehydrated onions are considered as a potential product in world trade. Rao and Ranganath (1995) reported that according to the International Trade Centre (ITC), Geneva, the demand of dehydrated onions in European Union (EU) alone was estimated to be more than 45,000 tonnes per year. Onions are generally dried from an initial moisture content of about 86% to 7% wet basis or less for efficient storage and processing. Dehydrated onions in the form of flakes or powder are in extensive demand in several parts of the world, for example UK, Japan, Russia, Germany, Netherlands, Spain etc. (Sarsavadia et al., 1999).

Dehydration of food is aimed at producing a concentrated product, which when properly packaged has a long shelf life, after which the food can be simply reconstituted without substantial loss of flavour, taste, colour and aroma. Removal of moisture prevents the growth and re-production of micro organisms that cause decay and minimize moisture mediated deterioration. Dehydration also enhances storability of products under ambient temperature.

The common preservation techniques followed for onion worldwide are mostly sun/solar drying (Bhatnagar and Ali, 1989; Bennamoun and Belhamri, 2003; Sarsavadia, 2007), and hot air drying (Sharma and Nath, 1991; Kaymak-Ertekin and Gedik, 2005; Sarsavadia et al., 1999; Elustondo et al., 1996). However, these methods demand long drying time as well as high processing temperature, affected by daily fluctuation of weather thereby making it difficult to maintain the product moisture content and quality properly because of air borne dirt and dust (Lee et al., 2006; El-Beltagy et al., 2007). Some other methods experimented recently are microwave drying and infrared drying alone or in combination with convective drying (Sharma et al., 2005; Pathare and Sharma, 2006) or osmotic dehydration (Sutar and Gupta, 2007).

Hence, there is a need to develop suitable technology by which we can minimize the losses and to offer millions of its consumers ready to use good quality dehydrated onions. The new industrial policy has placed the processed fruits and vegetables in the list of high priority areas, hence **v**alue addition and processing is a tremendous potential area now-a-days.

Suitable dehydration technique for onion can be characterized by proper colour and flavour retention, good rehydration ratio, less damage in the pore structure with extended storage period. In case of thermal treatment of onion, colour is produced due to the interaction of reducing sugars and amino acids, better known as non-enzymatic browning. This reaction produces brown coloured compound and induces off flavour. Hence reduced brown colour development can be an index of good quality dried onion. Flavour content of onion can be quantified either by pyruvic acid or thiosulfinate concentration because after cutting or crushing, onion produces pyruvate and thiosulfinate by enzymatic activity.

Drying phenomena can be combined with proper pretreatments often to ensure better product characteristics. For onion slices, dipping into Salt and sulfite solutions and osmotic treatment can be applied effectively. Pretreating the vegetables can decrease browning during processing and storage and lower the losses of flavours and of vitamins.

Vacuum enhances the mass transfer because of an increased pressure gradient between the inside and outside of the sample to dry and maintain a low temperature level essential for thermolabile products (Pere and Rodier, 2002). Vacuum drying allows effective removal of moisture at a low temperature under low pressure (Montgomery et al., 1997; Jaya and Das, 2003) and low oxygen environment thus maintaining efficient product quality for thermo labile products (Wu et al., 2007). Better product quality such as taste, flavour, rehydration ratio can be achieved by high degree vacuum treatment (Drouzas and Schubert, 1996). Vacuum drying has been used mainly for pharmaceutical industries or fruits and vegetables which are supposed to retain good nutrients and volatile aroma. Generally medium vacuum level 5 – 25 kPa is used for dehydration of fruits and vegetables under vacuum (Arevalo–Pinedo and Murr, 2005).

Further, to analyse the drying behaviour of onion under vacuum, numerical modelling approach has been employed. Vacuum drying of sliced onion is a complex phenomenon involving simultaneous heat and mass transfer accounting for the variation of operating conditions and product properties. Computational Fluid Dynamics (CFD) is an efficient tool that has been applied in modelling these kinds of complex physical phenomena of fluid flow and heat and mass transfer. CFD was first originated for the need of automotive and aerospace industry but became very popular among various chemical process industries and food sector also. Its use widened after several commercial userfriendly CFD code became available such as FIDAP, ANSYS, CFX-4, Phoenix, Fluent and COMSOL Multiphysics 3.3a etc. Some recent work on use of CFD in food engineering field has been attempted by Mondal (2009), Chourasia and Goswami (2006), Sahu et al. (1999), Cortella et al. (1998), Kieviet et al. (1997), Kumar (1995) etc. CFD can help to get a clear insight during heat and mass transfer phenomena occurring inside onion slice during vacuum drying.

Keeping the above points in view the present study on development of process technology to produce good quality dehydrated onion slices by vacuum drying was taken up with the following objectives:

1. To study the effect of pre treatment, slice thickness and drying temperature on the drying kinetics of onion under vacuum condition.
2. To model the vacuum drying process of onion slices using Computational Fluid Dynamics (CFD).
3. To study the quality parameters of dehydrated onion slices.
4. To optimize the process parameters of vacuum drying of onion slices.
5. To study the sensory analysis of the vacuum dried onion-tomato paste using fuzzy logic modelling.
6. To characterise the optimized product and estimate the shelf life based on quality degradation kinetics of dried onion slices.