Chapter 1

Introduction

1.1. Introduction and background of the present work

The Indian economy is poised to achieve a double-digit growth rate. Increasingly, India is being regarded as the economy to watch and various projections suggest that India would be the second largest economy by 2050. However, this success story hides a larger worry on the agricultural front. The share of agriculture sector in GDP has declined from around 35 per cent (in 1990-91) to around 27 per cent (in 1999-2000) and further to merely 18.5 per cent during 2006-07. The annual average growth rate for the agriculture sector was merely 3 per cent in the first five years of the new millennium. Thus, the agriculture sector is proving to be a drag on the economy. With more than half the population depending directly on this sector, low agricultural growth has serious implications.

Further, the food grains production is actually declining which can have its own impact on the food security of the country. To secure food for everyone, the revitalization of agriculture sector is needed and for this, the growth of food processing industry has to be ensured. Since, the food processing industry can address the key issues of wastages and value addition, and attract new investment in the sector. In addition, global experiences indicate that agriculture development in the country can be given a big boost by the growth of agro and food processing industries.

India currently produces about 50 million tonne of fruits, which is about 9 per cent of the world’s production of fruits and 90 million tonne of vegetables, which accounts for 11 per cent of the world’s vegetable production. However, only about 2 per cent of the fruits and vegetables in India are processed, which is very low compared to countries like the Philippines, Malaysia, USA, China and others. Lack of processing and inadequate storage facilities, for fruits and vegetables, results in huge wastages. Among the fruits, mango (*Mangifera indica* L.) is the oldest, tropical (Hashim et al. 2006), most popular (Rajkumar et al. 2007), climacteric (Chien et al. 2007), attractive (Sabato et al. 2009) and considered to be the king of fruits of India (Jha et al. 2010; Rathore et al. 2007). Indian subcontinent is
cultivating mango for well over 4000 years and mango is native to Southern Asia, especially Burma and Eastern India. Later on it spread to outside of India, especially to Africa, Brazil, Caribbean and Central America (lagtiani et. 1988), during 632 to 645 AD (Iha et al. 2010). The details of the mango cultivars, cultivation and quality have also been mentioned in Ain-I-Akbari written by in Abul Fazl (Bose and Mitra 2001).

India ranks first in area and production of mango with 2.31 million ha and 12.75 million tonnes, respectively with share of 56 % production in the world. Today, India is growing nearly 1000 varieties of mango. It has high commercial value in the international fruit market and is liked by people for its rich luscious aromatic flavour and a delicious taste with evenly blended sweetness and acidity. Nutritionally, it is rich source of prebiotic dietary fiber, carotenoids, organic acids, polyphenols, provitamins, minerals, etc. (Anon 2010).

Though India is the world's largest producer of mangoes, but surprisingly, it accounts for less than one percent of the global trade because of lack of rapid, non-destructive and precision sorting methods for quality and safety assurance and many times our export consignments have been rejected at destination port due to detection of soft tissue and some bacteria inside mango and over, and under ripeness etc. Thus, to satisfy the increased awareness, sophistication and greater expectation of consumers, it is very necessary to improve quality evaluation techniques of food products (Brosnan and Sun, 2004).

In addition, the ultimate objective of production, post harvest processing, handling and distribution of fruits and vegetables is to satisfy the consumer. Consumer satisfaction is related to the quality which can be viewed as an absence of defects and a degree of excellence. The colour, size, shape, mass, volume and surface area, etc. are also important ‘parameters’, which are considerable during the sorting of mangoes. Thus, to evaluate the fruit’s quality, a number of methods have been developed by the researchers generally depends on quality orientation of any food products. Methods could be divided into two types as: analytical/objective methods and subjective/sensory methods. Both methods have their own advantages and disadvantages. Analytical methods are based on product attributes, whereas, subjective or sensory methods are consumer oriented. For scientific works we need to measure attributes numerically and thus may not be varied in those perspectives. Sensory
attributes changes with sensory panels, place, religion, society, and so on. Practically sensory method of quality evaluation is better for adoption in that region whereas the objective evaluation may be helpful in development of specific instruments for specific quality attributes. The objective methods too are of two types: one can be said as destructive methods and other nondestructive. Most destructive methods use small samples and utilize them during investigation and the used sample will not be again reusable by the consumers. Generally, destructive methods are based on chemical analysis and used at laboratory level. One drawback of destructive method is that it is not necessary that whatever attributes you have measured in sample will be closely related with bulk from where samples had been drawn. There must be substantial variations. In contrast in nondestructive methods, samples or bulk of materials even remain untouched and samples are not destroyed. It remains intact for consumer and consumer can use it even after testing.

There are several non-destructive techniques that have now been emerged potentially in the field of agriculture and its allied sectors. Some of them are as; computer vision, X-ray and computed tomography, magnetic resonance imaging, near infrared, ultrasound and electronic nose and eye, etc. Since, appearance is the first impression that the consumer receives and the most important component of the acceptance and eventually of the purchase decision. Computer vision one of them (non destructive techniques) has been adopted for quality evaluations of mango non-destructively on the basis of deferent surface parameters. In spite of this, different studies have indicated that almost 40 % of the consumer's decision regarding the purchase of food products is based on appearance. Shape is one of the subcomponents more easily perceived, although in general, it is not a decisive aspect of quality, except in case of deformations or morphological defects. In some cases, shape is a ripeness index and therefore an indication of flavor (Camelo, 2004).

Further, computer vision being an objective, consistent, quantititative, rapid, non-contact and non-destructive quality evaluation tool, has been attracting much research and development attention among the non destructive technologies from the food industries. A rapid development has been increasingly taking place on quality inspection of a wide range of food products (Sun, 2004; Timmermans, 1998). Gunasekaran (1996) reported that by the use of computer vision technology, food industries ranked among the top 10 industries. In
spite of above, medical computer vision or medical image processing is one of the most prominent application fields. This area is characterized by the extraction of information from image data for the purpose of making a medical diagnosis of a patient. Generally, image data is in the form of microscopy images, X-ray images, angiography images, ultrasonic images, and tomography images (Anon 2009). For more details of image processing application, interested readers can refer to papers and books (Gumus et al., 2011; Jackman et al., 2011; Patel et al., 2011b; Sun, 2008; Zheng et al., 2006a,b; Youssef et al., 2005; Du and Sun, 2004a; Chen et al., 2002; Gonzalez and Woods 2002; Zuech 2000; Ballard and Brown, 1982).

So far many researchers have been devoted considerably for effort towards the development of machine vision systems for different aspects of quality evaluation and sorting of agricultural products. As a result, new algorithms and hardware architectures have been developed for high-speed extraction of features that are related to specific quality factors of fruits and vegetables. A number of sorting systems that use computer-vision techniques for evaluating external quality factors are commercially available.

1.2. Objectives of the study

The research work of above mentioned title will be governed under following objectives:

- To identify specific quality attributes and common external defects, which govern the quality standards and market prices (destructive & non-destructive)
- To capture image using imaging systems and lighting regimes
- To process the captured images and develop algorithms to correlate the image properties with quality parameters

1.3. Thesis purview/organization

The thesis consists of five chapters. The first chapter illustrates the status of production of mango fruits in India and the importance of computer vision system among the several non-destructive techniques for food quality evaluation. The motivation for the present work and its objectives are highlighted therein. The second chapter contains the review of the relevant literature in the fields of non-destructive quality evaluations based on computer vision
system. An effort has been made to furnish up to date information on computer vision system and post harvest operations and management of mango fruits. Chapter 3 provides a brief description of the sample collection, the cameras used for image acquisition, the methodology of development of algorithms for physical characterization as well as for defect detection and data analysis procedure. Chapter 4 contains results and discussion which is divided into sections A & B. Section A discussed the results obtained from destructive/ subjective or laboratory or traditional methods. The results pertaining to monochrome, color, UV and NIR camera based computer vision system (non-destructive methods) are presented and discussed in the section B. The last chapter contains summary and conclusions drawn from this chapter. Finally, in this chapter, some recommendations have been made for further research in the light of above work done.