Food Chemistry 139 (2013) 689–694

Contents lists available at SciVerse ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Monitoring green leaf tea quality parameters of different TV clones grown in northeast India using satellite data

Rishiraj Dutta *

Asian Disaster Preparedness Center, Duty Station: ADPC-Bangladesh Office, Dhaka, Bangladesh

ARTICLE INFO

Article history:
Received 27 February 2012
Received in revised form 27 January 2013
Accepted 28 January 2013
Available online 9 February 2013

Keywords:
TV clones
NDVI
Statistical analysis
Quality
Monitoring

ABSTRACT

This study tries to quantify the effects of green leaf tea parameters that influence tea quality in Northeast India. The study is to identify the different parameters that have a significant influence on tea quality through the use of remote sensing. It investigates the methods for estimating tea quality based on remotely sensed Normalized Difference Vegetation Index (NDVI) data. Attention focused on high yielding TV clones (TV1, TV18, TV22, TV23, TV25 and TV26). NDVI was obtained from ASTER images. Statistical analysis shows that NDVI has a strong significant effect on the caffeine content followed by epicatechin (EC), epigallocatechin (EGC) and to some extent in other chemical parameters. Relationships therefore exist between quality parameters and remote sensing in particular for the TV clones. This leads to the conclusion that NDVI has a large potential to be used for monitoring tea quality of individual cultivars in the future.

1. Introduction

Tea is made from tender shoots of *Camellia sinensis* (L.) O. Kuntze (Hara, Luo, Wickremasinghe, & Yamanishi, 1995; Wright, Mphangwe, Nyirenda, & Apostolides, 2002). It is a leading cash crop in world agriculture (Dutta, Stein, Smaling, Bhagat, & Hazarika, 2010). Its production has increased from 850 million kg between 2000 and 2003 to 980 million kg between 2004 and 2007. Main tea producing countries are China, India, and to a lesser degree Sri Lanka, Kenya, and Indonesia. With the increasing world population, the tea market is expected to grow further (Tea statistics annual report: Growers, 2010). In India, however, stagnation in tea production and decline of tea quality are the major problems for the tea industry (Dutta, 2006). Several factors are contributing to this decline; ageing tea bushes, declining soil health, and increased incidence of pests and diseases, all results in deterioration of tea quality.

Factors like colour, appearance, flavour and mouth-feel jointly make up the quality of tea. These factors are influenced by the levels of chemical constituents present in the leaves (Wood & Roberts, 1964). Caffeine plays a vital role in tea quality characteristics such as briskness and other taste properties (Dev Choudhury, Rahman, & Barbora, 1991; Hilton & Ellis, 1972; Roberts, 1962; Sanderson, 1972) and it is an important parameter for the evaluation of tea quality (Khokhar & Magnusdottir, 2002; Owuor, Horita, Tsushida, & Murai, 1986; Yao et al., 2006). Caffeine is a white, bitter crystalline alkaloid and is a component that stimulates the nervous system. A cup of tea contains about 40 mg of caffeine. Most teas from North Indian regions have high (3.4–3.9%) soluble caffeine content, which may cause the high briskness of these teas (Borse, Rao, Nagalakshmi, & Krishnamurthy, 2002). Liquor brightness and colour are influenced as well by agronomic and processing conditions, such as plucking standards (Obanda & Owuor, 1995), handling of plucked leaf, withering and fermentation conditions of temperature (Owuor & Obanda, 1997), relative humidity and duration of fermentation (Obanda, Owuor, & Mang'oka, 2001).

The major tea leaf catechins include epicatechin (EC), epicatechin gallate (ECG), catechin (+C), epigallocatechin (EGC) and epigallocatechin gallate (EGCG) (Obanda, Owuor, & Mang'oka, 2001). The catechins differ in chemical structures, reduction potentials (Bajaj, Anan, Tsushida, & Ikegaya, 1987) and contribution to the astringent taste of tea (Ding, Kuhr, & Engelhardt, 1992; Kuhr & Engelhardt, 1991). Apart from their role in tea quality, catechins are increasingly being identified to benefit the human health (Apostolides & Weisberger, 1995; Cheng et al., 1986; Obanda, Owuor, & Taylor, 1996; Sano et al., 1991). ECG and EGCG are the main residual catechins in black tea (Obanda, Owuor, & Mang'oka, 2001). Flavonol glycosides are also present in the green tea leaf and contribute substantially to tea liquor colour (McDowell, Feakes, & Gay, 1991).

Understanding the spectral characteristics of tea plants is important for monitoring tea plantations by remote sensing. (Rajapakse, Tripathi, & Honda, 2002) developed an empirical model between Normalized Difference Vegetation Index (NDVI) and Leaf Area Index (LAI) of the tea canopy and revealed different tea clones

* Tel.: +880 1765189458
E-mail address: dutta13191@alumni.itc.nl

0308-8146/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.foodchem.2013.01.086

have unique spectral characteristics depending on the tea canopy structure, size and maturity of the leaves. Understanding the spectral characteristics of tea plantations is important for monitoring the growth of plants and estimating tea yield using remote sensing methods. The spectral characteristics of a plant canopy largely depend on the composite spectral response of leaves and soil background (Richardson & Wiegand, 1977). Reflectance signals of vegetation in the visible and near-infrared are used to detect distribution, health and productivity of plants (Buschmann & Nagel, 1993; Rajapakse et al., 2002). With the help of available field information, Remote Sensing (RS) and Geographical Information System (GIS) have become powerful tools successfully monitoring crop growing status and estimating yield (Dutta, Stein, & Bhagat, 2011). At the same time, the demand for monitoring quality has become more urgent. Therefore, attention has been given towards monitoring tea quality especially with regards to individual cultivars through remote sensing and GIS.

The important chemical constituents which influence the taste and flavour in tea brew are polyphenols, caffeine, sugars, organic acids, volatile flavour compounds and amino acids. Caffeine is responsible for the briskness. The volatile flavour compounds of tea and their variation in composition due to geographical and other process variables are of paramount importance from a quality point of view. It is also known that the chemical and quality variations occur due to the variation in the genetic make-up of the plants, even when they are grown under similar conditions in one environment (Owuor, Obanda, Nyirenda, & Mandala, 2008).

Quality monitoring is usually done through laboratory analysis. Vegetation indices obtained by remote sensing have not been extensively used in monitoring tea quality. Phenology and vigour are the main factors that affect NDVI. Healthy vegetation contains large quantities of chlorophyll. Reflectance in the green and near infrared spectral regions is high for healthy plants because of a high reflectance of infrared light, and a relatively low reflectance of red light. Reflectance in the blue and red parts of the spectrum, however, is low, since chlorophyll absorbs this energy. A recent study by Dutta et al., 2011, suggested NDVI could be used for monitoring tea quality and using NDVI and NIR spectroscopy, they derived relationships based on desirable qualities in green leaf and black teas.

Based on the earlier study of Dutta et al., 2011, the present study aimed to understand the relationships between remotely sensed data (NDVI) and green leaf tea quality parameters in six major TV clones grown in Northeast India. The study was carried out on one tea estate in the Assam region of Northeast India.

2. Materials and methods

2.1. Study area

The study area was located in the Jorhat district, in the South Bank region of Assam, India (26.7° N latitude and 94.2° E longitude, average elevation of 116 m). The surrounding Jorhat district spreads over 2851 m^2. Summer temperature ranges between 15 and 28 °C, and winter temperature between 7 and 18 °C. Summers are accompanied by the monsoon showers leading to an average annual rainfall of 2244 mm. There are approximately 135 tea estates including 'out' gardens that occupy an area of 2690 km^2 (Jorhat District Profile: National Informatics Centre, Government of India). This study was carried out at the estate 'SE' located in the area (Fig. 1). The estate has several sections each of sizes ranging from 10–15 ha. Each section consists of different clones or seedlings and is managed on the individual basis.

2.2. Data used

2.2.1. Leaf collection

Leaves were collected from the TV clones (TV 1, TV 18, TV 22, TV 23, TV 25 and TV 26) that were planted in different sections. These clones were selected on the basis of good fermenting ability. Plucking was carried out at seven-day interval from 18th April to 20th June, 2011. The clones were plucked in the afternoon hours between 2 and 3 pm. The plucking was done in the late afternoon hours to minimize moisture content in the leaves. The two leaves and a bud method were followed. In total, 1 kg of leaves was plucked by the same pluckers who maintained 65–75% leaf fineness. Quality of the leaf samples was analyzed with special reference to total polyphenols content and catechins profile.

2.2.2. Satellite data

For this study, an ASTER image acquired in May, 2011 was used for estate SE based on cloud free conditions. The ASTER scene covers an area of approximately 60 km by 60 km. The image was georeferenced to the WGS-84 datum and Universal Transverse Mercator (UTM) projection. The scenes are rotated from true north to produce a smaller dataset.

Data at three resolutions were acquired simultaneously. A complete ASTER scene consists of 15 bands of data. The three useable bands in the visible and near infrared (VNIR) part of the spectrum have a 15 m resolution and an 8-bit unsigned integer data type. This data set also features a near infrared backward scanning band

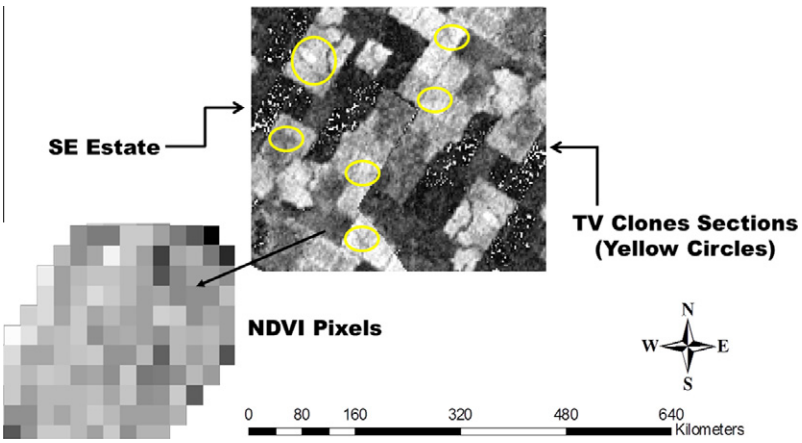

Fig. 1. NDVI map showing the sections of TV clones of Estate SE, Assam, Northeast India.