Electronic Nose – A new way for predicting the optimum point of fermentation of Black Tea

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ABSTRACT*: Fermentation is a very important key of the black tea quality and this stage of the process, making finished tea is responsible to make better quality black tea in the sense of appearance, aroma, liquor and infusion. At the time of fermentation grassy smell continues change to the floral smell due to some complex chain of biochemical reaction inside the tea leaf and greenish color changes into the coppery brown .The detection of optimum time for fermentation is very crucial part to tea manufacturer, because under fermentation and after fermentation may be responsible for the bad quality of tea. So this process had to be stopped at the time of optimum fermentation with reference to the Aroma index by electronic nose changes during fermentation as well as color (RGB value) by electronic version. In this paper we study the changes of Aroma index (sensor response) and color (RGB value) during the fermentation process and to detect the optimum fermentation time by using electronic nose and electronic vision Kharagpur region black tea.*

Keywords - *Electronic nose; electronic vision; aroma index; RGB value.*

I. INTRODUCTION

Tea is now becoming a most consumed beverage in the world. Scientific name of Tea is (camellia sinensis). Tea is popular because of its advantage in different fields. It has some medicinal consequence like antibacterial antiquaries, anti cancer, anti allergic, antiobesity etc. it has its own test of flavor. India is producing a good amount of tea and exporting all over the world. Tea is traditionally classified based on the techniques with which it is produced and processed. [1]

White tea:	Wilted and unoxidized
Yellow tea:	Unwilted and unoxidized, but allowed to yellow
Green tea:	Unwilted and unoxidized
Oolong:	Wilted, bruised, and partially oxidized
Black tea:	Wilted, sometimes crushed, and fully oxidized
Post-fermented tea:	Green tea that has been allowed to ferment/compost

In this paper we found that the optimum fermentation time of Kharagpur region black tea with the help of electronic nose & vision and tea expert feedback tea fermentation is basically the oxidation process of simple compound into complex characteristic substance by some enzymes present in the tea leaves these enzymes start their reaction when tea leaves just after macerated in first stage they make grassy smell peak and then after some time, In the second stage they make some floral smell. This is a very crucial time when we stop the fermented process. The black tea manufacturing process of Kharagpur region is given below.

Plucking
Withering
Maceration
Rolling
Fermentation
Drying
Gradation

Plucking is a very important part in the manufacturing. The ideal is two leaves and a bud in a continuous interval of 7 to 10 days. In withering process the moisture content reduce to approx 85% to 70% in an approx timing 10 to 12 hours. In maceration process CTC machine (crush tear and curl) where tea leaf size is reduced to 2 to 4 mm and just after the CTC fermentation process starts. In this stage some biochemical chain reaction takes place this cause some change in tea leaves like greenish color changes in coppery brownish color and some grassy smell converts to some floral smell this is a very crucial part of the tea manufacturing because under fermentation and after fermentation may cause to produce bad quality of tea . So we have to stop this process at the optimum point for making good quality tea. In a drying stage it dry at the temperature 80 to 120 degree centigrade about 20 to 30 minutes in a drier till moisture content remain 3 to 4 % in a finished product. After this it goes for gradation and packaging.

II. ELECTRONIC NOSE & VISION SETUP

The An electronic nose setup has been developed by CDAC Kolkata for assessment of quality of tea aroma. An electronic nose consists of (1) sensor array , (2) micro pump for supply volatile compound to the sensor array (3) solenoid valves (4) PC based data acquisition (5) illumination heating halogen bulbs (6) olfaction software. And electronic vision consists of LED light and 2 mega pixel camera.

An electronic nose sensor array is set of eight metal oxide semiconductor (MOS) sensor (TGS-832, TGS-823, TGS-831, TGS-816, TGS-2600, TGS- 2610, TGS-2611 and TGS-2620) for response of volatile compound in a black tea (1-Pheyl-ethanol, benzaldehyde, β-ionone, geraniol, linalool, linalool oxide, terpeniol, etc.). Metal oxide semiconductor (MOS) sensors are cunductometric, when volatile compounds react with these sensors then resistance decreases. The change resistance ΔRs with their initial resistance Rs. (ΔRs/Rs) is converted into voltage this voltage value shows the intensity of vapor molecules and through the olfaction software all value of sensor response makes a one calculated value which is called NORMAROMA index. If the intensity of volatile compound is more, than the aroma index will be more.

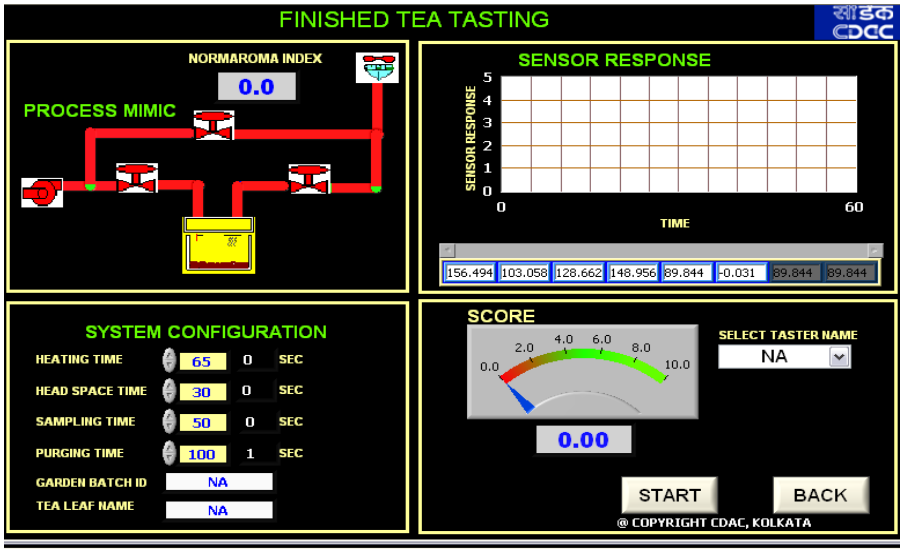

Fig. –(1) Screenshot of enose setup

Process of Electronic nose & vision setup during fermentation of black tea is given follows.

Weight of sample	= 50 grams,
Temperature	= ambient,
Heating time	= 65 seconds,
Head space time	= 30 seconds,
Sampling time	= 50 seconds,
Purging time	= 100 seconds,
Air flow rate	= 5 ml/seconds,

The initial value of sensors defined by CDAC Kolkata.

Sensor 1	Sensor 2	Sensor 3	Sensor 4	Sensor 5	Sensor 6	Sensor 7	Sensor 8
0.657237	1.447171	1.075114	0.882861	0.955383	1.414711	0.535694	1.243104

III. FERMENTATION PROCESS MONITORING USING ELECTRONIC NOSE

An experiment was carried out at the Indian institute of Technology Kharagpur which is premiering technology & research institute in India. The institute has an own tea garden for research purpose producing adequate amount of black tea, orthodox and green tea. There was a long trial has done in this institute, altogether, 18 fermentation cycles has been considered for data collection out of which 9 were with high humidity tea leaves a remaining 9 cycles took as a normal condition of the environment by using electronic nose & vision.

In this method we took a 50 gram. A sample of just after macerated tea leaves and then put into the electronic nose for observation and when this observation is going on we prepare another 50 gram. Of sample and when 1st sample observation complete then took the Aroma index and all sensor responses and note down the data, then we put the 2nd sample into the e-nose as like this we put a sequence of sample for observing the data by electronic nose. By using this data we plot a graph between time and aroma index then we found that there was a 1st peak comes out having a high intensity of smell called grassy smell and then smell intensity becomes low and again there 2nd peaks comes out having very high intensity of some floral smell. And then took 9 and 9 data made all average to them and finally draw a graph of mean calculation aroma index average 1 on 1st 9 data which is taken in high humidity and 2nd 9 data we took at normal condition of the environment .So the graphs are given below in Fig. (2) Fig. (3) . The sensor response during the fermentation process is shown in fig. (4)

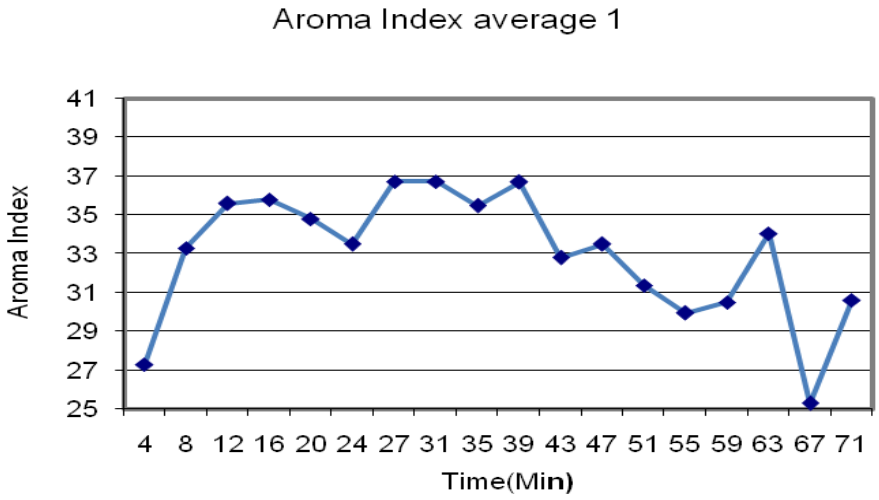

Fig.(2) Graph between aroma index and time in minutes

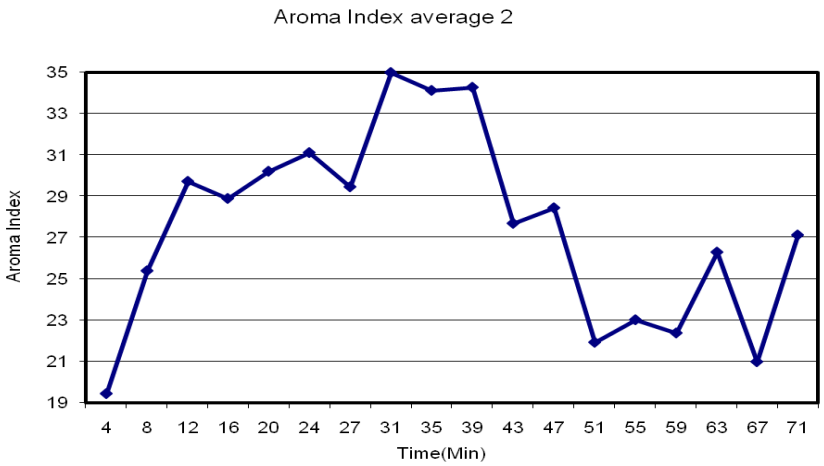

Fig. (3) Graph between aroma index and time in minutes

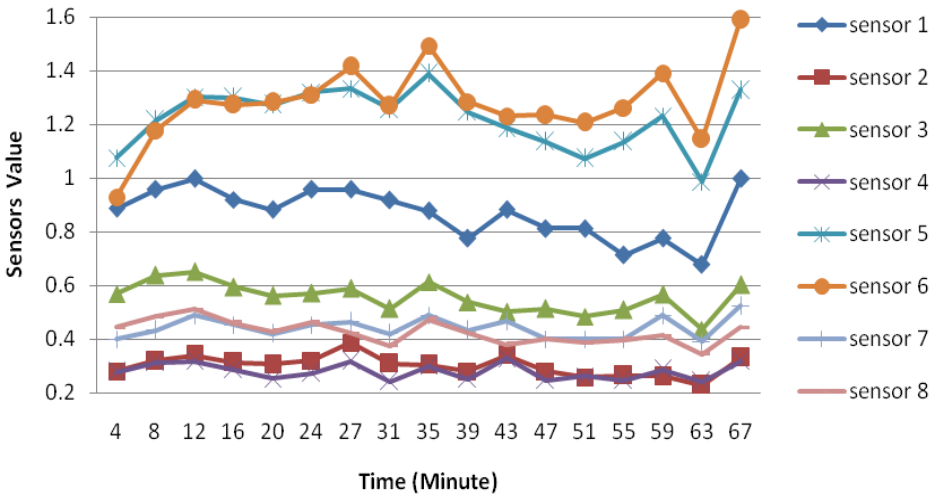

Fig. (4) Graph between sensors response and time in minutes

IV. COLOR STUDY AT THE TIME OF FERMENTATION

Color is a very important part of the fermentation process to detect the fermentation time (Chakravorty, 1976). Now CDAC Kolkata has developed an electronic vision for detecting optimum time for fermentation. In this method we took a 50 gram sample and spread it on porcelain plate for fermentation and check its color change during fermentation by using electronic vision at each interval of 5 minutes. Covert that image into 3×3 pixels with the help of ADOBE PHOTOSHOP CS3 EXTENDED software and then count each pixel color component in the RGB (Red, Green, Blue) form and then we got 9 pixels data after that we made an average of that all data and convert them in the % of RGB component of a single image. By using this process we analysis all images which we have taken and draw a graph between times reached optimum and percentage of RGB as in Fig. (5). When the fermentation time reached to the optimum point, color becomes coppery brown from greenish color. Time of optimum color point had been noted for each fermentation experiment and result has been correlated with the electronic nose result and human expert feedback.

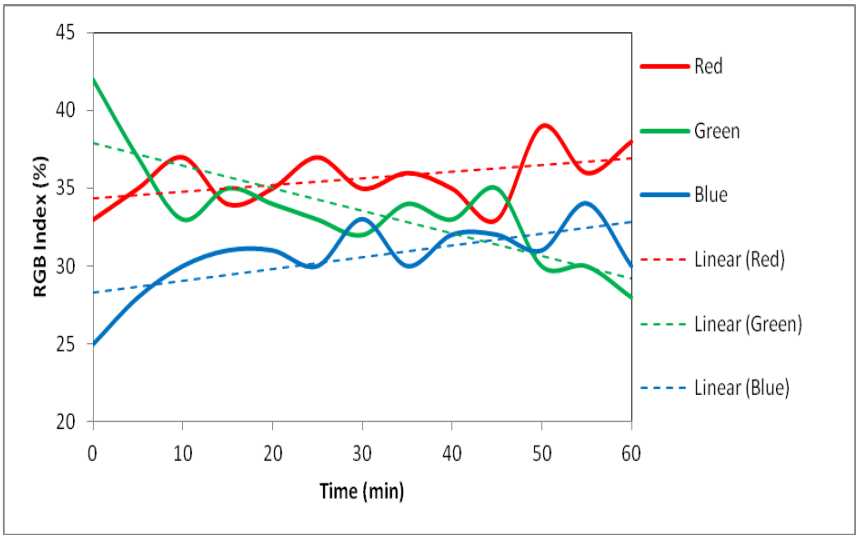

Fig. (5) Graph between RGB component % and Time in minutes

The intensity of green color decreased during the interval 0 to 60 minutes of the fermentation process. This evident from the graph as the % of color pixel in unit area decreased to 42% to 30% during the interval this shown in fig. (2) During the same time interval the %of red color pixels increase from 33%to 36% and that of the blue collar increase from 25% to 34%. The trend line shows that at fermentation process green color index decreases, while red and blue color index increases.

V. HUMAN EXPERT FEEDBACK DATA

As traditional method to find out the optimum point of fermentation time is human expert. They are very experienced and working for a long time for tea manufacturing or tea research. In this process the human expert observed the color change during the fermentation and he checks every time interval of 5 minutes. When tea leaves become coppery brown from greenish color and appearance look good as according to the human expert then they stop the fermentation process and send it to for drying process as another way parallel to the above experiment human expert detect the optimum fermentation by manually smell. In this method the human expert pick up a sample of fermented tea and smell it at each interval of 5 minutes when fermentation started the smell intensity is low, when time goes up then a first smell peaks comes out which is like the grassy smell and then this smell intensity goes down after some more time again second smell peak comes out which like some floral smell. Then human expert correlates color and smell and when he satisfies with aroma and color then he stops that fermentation process and send it for drying for better tea quality. The experiment was carried out Tea Research Building, Indian Institute of Technology, Kharagpur. As a human expert Late Prof. Hrishikesh Das and Mr. Bhanu Mukharjee involved in human evaluation test for the fermentation runs under experimentation. He sniffed a handful of teas in fermentation every interval of time and declared the optimum fermentation time using their experience olfactory senses.

VI. RESULT AND DISCUSSION

In this experiment we found that the optimum fermentation time can be achieved with electronic noise and electronic vision which is quite similar to the human experts feedbacks. Here we achieve the optimum time of fermentation of two different relative humidity 1st 9 samples in the relative humidity range 60 – 70 at room temperature 25-30 degree C and 2nd 9 samples with a relative humidity range 70-90 % at room temperature 25-30 degree C with electronic nose average of 63 and 65 min respectively, which is in the range of tested with human experts and electronic vision. The Electronic nose &Vision is a very beneficial to predict the optimum fermentation time of the black tea. By the above correlation between Electronic Nose & Vision and human expert data we can predict any tea optimum fermentation time. This will be responsible for very good tea quality.

Comparison of results

S. No.	A place to experiment	Time of experiment No. of fermentation runs	Relative humidity range (%)	Temperature (^{o}C)	Time ranges for fermentation completion (Min)	Electronic vision result (Min)	Human evaluation (Min)	Electronic Nose results (Min)
1	IIT, kgp	9	60 - 70	25 - 30	55 - 60	55 - 60	60 -70	63
2	IIT, kgp	9	70 - 90	25 - 30	65 - 70	60 -70	65 -75	65

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