Sensors and Materials, Vol. 23, No. 8 (2011) 501–506
MYU Tokyo

S & M 0863

Evaluation of the Taste of Tea with Different Degrees of Fermentation Using a Taste Sensing System

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(Received September 1, 2011; accepted September 22, 2011)

Key words: taste sensor, fermentation process, green tea, oolong tea, black tea, postfermented tea

From a health viewpoint, the number of persons who begin to drink tea is increasing yearly. There are over 500 traditional medicine books and papers describing the usefulness of tea for health, medicine, and pharmacy purposes in China. Tea is a type of beverage that humans prefer because of its color, aroma, and taste. Thus, the value of tea is determined on the basis of a comprehensive human sense. The senses of sight, hearing, and touch are used to perceive such single physical quantities as light, sound waves, and pressure (or temperature), respectively, whereas the senses of taste and smell are used to perceive chemical quantities derived from many types of chemical substances. Therefore, there is difficulty in developing sensors for taste and smell. For this reason, sensory tests to evaluate the taste and smell of tea have been used although they are subjective. Most types of tea are made from the same plant but with different fermentation processes. In this work, using a taste sensing system TS-5000Z that has been successfully used for evaluating the taste of various foodstuffs, first, we evaluated the effects of fermentation, from fresh leaves, withering leaves, and rolling leaves, on the taste of tea. We found that the astringency level and umami taste level are decreased, whereas the bitterness level is increased with the degree of fermentation. Next, as an experiment to obtain actual proof, we evaluated the differences in the tastes of green tea, oolong tea, black tea, and postfermented tea, which were made with different degrees of fermentation. The result shows that it is possible to distinguish the differences in these teas. All these results show the possibility that the taste sensing system can be used in the quality control of tea fermentation.

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1. Introduction

It is well known that tea is very useful for health,[1–4] but few people know that many types of tea, such as black tea, green tea, and oolong tea, come from the same plant and their taste depends on the manufacturing process. One of the key steps in the tea manufacturing process, which is a factor in determining the types of tea, is the degree of fermentation. The term "fermentation" in the tea industry is something of a misnomer, as the term actually refers to how much a tea is enzymatically oxidized by drying freshly picked tea leaves. As an all-inclusive term in the tea manufacturing process, it is called fermentation in the following procedures: 1) tea plant, 2) picking leaves, 3) withering leaves, 4) rolling leaves, 5) oxidizing leaves, 6) drying leaves, and 7) grading leaves. In this fermentation process, procedures 3 and 4 are characterized by major chemical changes. The chemical changes are also processed in step 5; however, the major changes occur by step 4.

In this work, using a taste sensing system TS-5000Z (Intelligent Sensor Technology, Inc., Japan) that has been used in quantifying the taste of tea,[5,6] we first evaluated the changes in the taste of teas by fermentation processes, mainly procedures 3 to 5, ranging from fresh leaves, withering leaves, rolling leaves, and oxidizing leaves. Next, we evaluated the effect of the degree of fermentation on the taste of teas, such as green tea, oolong tea, black tea, and postfermented tea.

2. Materials and Methods

2.1 *Measurement setup*

The TS-5000Z Taste Sensing System was used for measuring the taste of the tea samples. Figure 1 shows a diagram of the taste sensing system, which is composed of a sensor unit and a management computer. Taste sensors are composed of an artificial lipid-based membrane containing artificial lipids and plasticizers. These artificial lipid-based membranes react with taste substances, and the electric potential of the membrane changes on the basis of electrostatic and hydrophobic interactions. This potential change is detected as the sensor output and evaluated as taste information by the computer.[7–10] Table 1 shows the components of taste sensors used in this work. These sensors, which are designed for detecting different tastes, have very high selectivity for taste materials. For example, the astringency sensor responds only to astringent substances and the bitterness sensor responds only to bitter substances.[11]

2.2 *Test methods and samples*

Six types of leaf for black tea, ***benifomare*** (made in Japan), with different degrees of fermentation were used as samples: fresh leaves, withering leaves, rolling leaves, and three types of leaf fermented in 1, 2, and 3 h. Three grams of each leaf was extracted in 200 ml of boiling water for 3 min to obtain a measurable sample (Table 2).

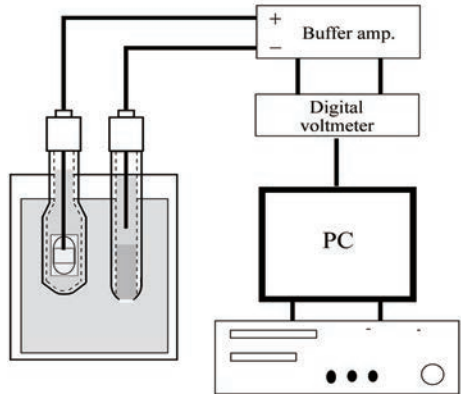

Fig. 1. Diagram of taste sensor and taste sensing system.

Table 1
Components of Lipid Membrane.

Ch.	Lipid	Plasticizer	Taste used for
1	tetradodecylammonium bromide	di-*n*-octyl phenylphosphonate	astringency
2	tetradodecylammonium bromide	2-nitro phenyloctyl ether	bitterness
3	phosphoric acid di(2-ethylhexyl) ester trioctylmetylammomium chloride	di-*n*-octyl phenylphosphonate	umami taste

Table 2
Tea samples.

No.	Sample Name	Type*	No.	Sample Name	Type*
1	Ceylon Low Grown	B	14	Iron buddha tea	O
2	Keemun	B	15	MENGHAITUOCHA	P
3	Ceylon Med. Grown	B	16	Fu-cha	P
4	Indonesia	B	17	Awa-bancha	P
5	Assam	B	18	Batabata-cha	P
6	Ceylon Uva	B	19	Ishizuchi-kurocha	P
7	Ceylon High Grown	B	20	Goishi-cha	P
8	Dimbula	B	21	Yutakamidori	G
9	Darjeeling	B	22	Ooiwase	G
10	Pouchong tea	O	23	Okuyutaka	G
11	Kinzan tea	O	24	Yumekaori	G
12	Oriental beauty	O	25	Sawamizuka	G
13	Dongding tea	O	26	Yabukita	G

*Note: B: Black tea, O: Oolong tea, P: Postfermentation tea, G: Green tea.

3. Results and Discussion

3.1 *Evaluation of the change in the taste of tea due to fermentation*

Hayashi's group reported on the quantification of the astringency and umami taste of green tea using a taste sensing system, showing that the system is useful for the quantification of the taste of tea.[5,6] We used the same taste sensing system to evaluate the taste of tea objectively, particularly for teas with different fermentation degrees. Most types of tea are made from the same plant but with different fermentation processes and degrees of fermentation. Figure 2 shows the difference in the degree of fermentation, where a tea sample made with fresh leaves was used as a control and its taste information was set to zero. The result shows that the bitterness and umami taste are enhanced, whereas the astringency level decreases as the fermentation progresses. This result agrees well the generally accepted findings.

3.2 *Evaluation of the difference in the degree of fermentation of various teas*

Depending on the degree of fermentation, teas are divided into green tea, oolong tea, black tea, and postfermented tea. We evaluated the difference in twenty-six types of these teas using a taste sensing system. Figure 3 shows the result of principal component analysis (PCA) based on the information on the strengths of astringency, bitterness and umami taste obtained from taste sensors. The *x*-axis represents the first principal component with 70.52% of the contribution rate, while the *y*-axis represents the second principal component with 19.05% of the contribution rate. The result shows that the samples are plotted in the order of green tea, oolong tea, black tea, and postfermented

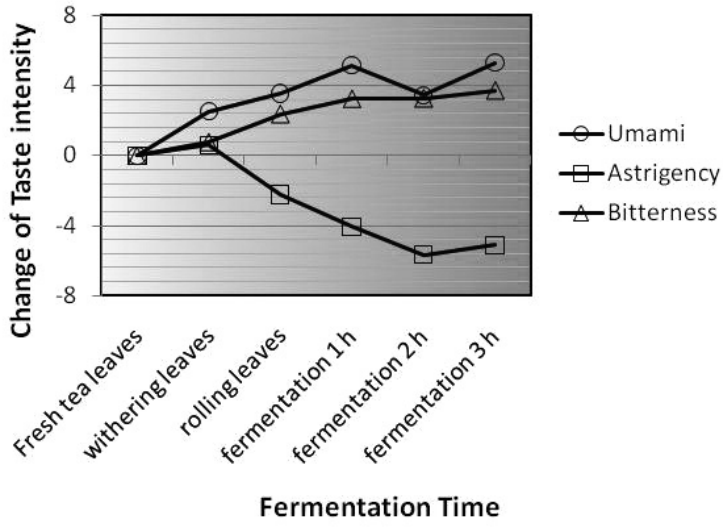

Fig. 2. Change in the taste of tea with different degrees of fermentation.

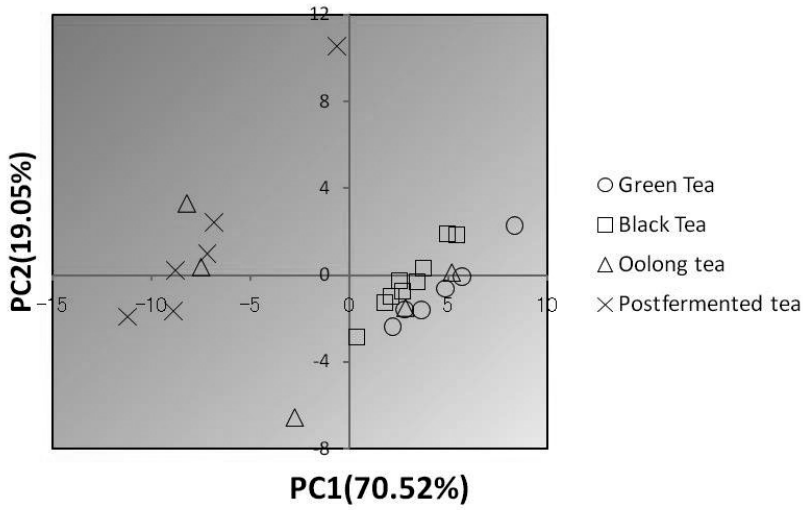

Fig. 3. Taste map of teas.

tea, suggesting that the order agrees well with the degree of fermentation. Two samples of oolong tea, "*Oriental Beauty*" and "*Dongding*," are plotted away from other oolong tea samples, near a group of postfermented teas. This implies that *Oriental Beauty* was fermented more effectively by insects, whereas *Dongding* was oxidized more extensively by repeatedly performing the rolling process. We will determine the reason why the two oolong teas showed such plots.

4. Conclusions

In this work, first, we objectively evaluated the change in the taste of teas with different degrees of fermentation using a taste sensing system and found that the astringency and umami taste are diminished, while the bitterness level increases with increasing degree of fermentation. Second, we evaluated the difference in the taste of four types of tea, namely, green tea, oolong tea, black tea, and postfermented tea, and found that the result of PCA analysis based on the taste information of astringency, bitterness and umami taste is in good agreement with the order of the degree of fermentation. This demonstrates that the taste sensing system can be used effectively in the quality control of tea fermentation.

In the future, we will create a database on the different tastes of teas with several parameters, including harvesting season, methods of fermentation, and ways of brewing. We hope that this technology will contribute to the development of the tea industry in the world.

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