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DETECTION OF BITTERNESS – SUPPRESSION USING A TASTE SENSOR

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Abstract

We tried to detect the suppression of bitterness with a taste sensor. Quinine hydrochloride, which has a positive charge usually cause large potential change of negatively charged membranes of the sensor. The potential change was decreased by sour substances such as acetic acid. The decrease of the potential change of response implies a decrease in the intensity of bitterness. Contrary to this, response of the sensor to sodium picrate, which has a negative charge, was diminished by sodium salts of organic acids. As the hydrophobicity of organic acids increased, the suppression of bitterness also increased. The present study is expected to provide a new quantitative technique to measure the strength of bitterness of foods and drugs in place of sensory evaluation.

Keywords: Taste sensor, Membrane potential, Quinine hydrochloride, Sodium picrate, Suppression of bitterness.

Introduction

Taste is composed of five basic qualities of sourness, saltiness, sweetness, bitterness, and umami. Among these taste qualities, bitterness is usually an undesirable taste, because it is a sign of harmful substances. It is important for food and pharmaceutical sciences to suppress the bitterness1). To date, however, the main method of measurement is sensory evaluation by humans, in which tasting bitterness stresses inspectors. Hence, taste-sensing devices which can detect the bitterness have been desired for a long time. A taste sensor whose transducer is composed of several kinds of lipid/polymer membranes with different characteristics can detect taste in a manner similar to human gustatory sensation2~4). Taste information is transformed into the pattern composed of electric signals of the membrane potentials. In this study, we applied the taste sensor to bitter substances coexisting with ingredients of food and attempted to detect the suppression of bitterness.

Materials and Methods

Chemicals

Quinine hydrochloride and sodium picrate were used as bitter samples. Quinine hydrochloride was obtained from Sigma, and other chemicals such as sodium picrate and sodium salts of organic acids were from Wako.

Lipid membranes

The taste sensor with a multichannel electrode was similar to that previously reported2~4). Eight lipids were abbreviated as follows: dioctyl phosphate, C; trioctylmethylammonium chloride, T; oleyl amine, N; decyl alcohol, DA; oleic acid, OA. Lipid membranes designated C:T=9:1, C:T=3:7 and C:T=5:5 are mixtures of two lipids for which the ratio shows the molar concentration. The membranes of C:T=3:7, T, and N are positively charged, whereas of C:T=9:1, C, DA and OA are negatively charged. The membrane C:T=5:5 is almost totally neutral.

Measurements using a taste sensor

The electric potential across the membrane was detected by a Ag/AgCl electrode filled with 100 mM KCl and a reference electrode (TOA, HS205C). The construction of the measuring system is as follows: Ag/AgCl electrode in 100 mM KCl solution │membrane │ reference electrode in taste solution. The membrane potential was changed by applying taste substances, and the electric signal from each membranes was converted into a digital code using a digital voltmeter through a high-input impedance amplifier and a laboratory-built eight-channel scanner, and recorded in a computer.

Results and Discussion

Bitterness of quinine hydrochloride

Quinine hydrochloride is one of the most popular bitter substances, therefore the studies to depress the bitterness have been carried on it5~7). Response of the sensor to quinine hydrochloride was measured relative to 1 mM KCl solution (Fig. 1). As the quinine concentration increased, the response potentials of the negatively charged membranes such as C, 9:1, DA and OA increased. The increase in the potential of negatively charged membrane is because quinine hydrochloride become positively charged with ionization and hence is adsorbed strongly to the membrane with its hydrophobicity. Accordingly, the negative charge of C, 9:1, DA and OA membranes are reduced by the shielding effect of quinine ions, thus increasing the membrane potential. On the other hand, the positive charge of 3:7, T and N membranes are reduced by the shielding effect of chloride ions, thus decreasing the membrane potential.Effect of food constituents on the bitterness of quinine hydrochloride was investigated, because it is considered that among the great deal of chemicals the constituents are quite safety. Typical food constituents such as sucrose (100 mM),

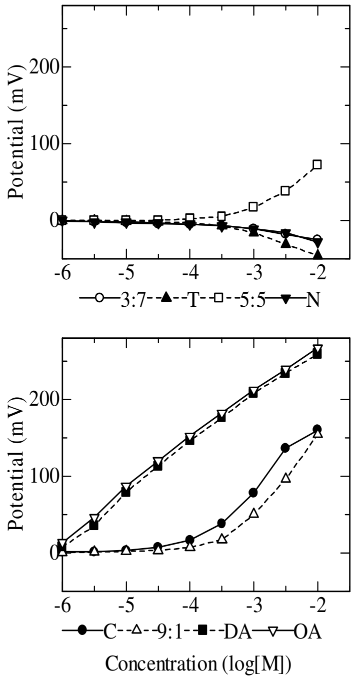

Fig. 1: Response of the taste sensor to quinine hydrochloride

Typical food constituents such as sucrose (100 mM), NaCl (100 mM), monosodium glutamate (MSG, 10 mM) and HCl (1 mM) were added to standard solution, 1 mM KCl, and the response of the sensor to quinine hydrochloride were measured. The response of the negatively charged membranes in the presence of sucrose and HCl were shown in Fig. 2. The potential change was depressed by HCl. The depression of the potential change of response implies a decrease in the intensities of bitterness.

Hydrogen ions have shielding and adsorbing effect on the negatively charged membranes, hence its blocking may be strong. Sucrose, MSG and NaCl were much less effective than HCl.

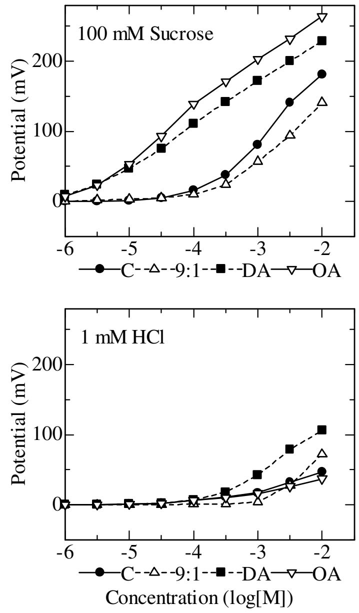

Fig. 2: Effect of sucrose and HCl on the response of the sensor to quinine hydrochloride

Organic acids such as glutamic, acetic, lactic, malic and citric acid also depressed the bitterness. From the results obtained in Fig. 1, it is roughly estimated the relation between quinine concentration and electric response. Figure 3 indicates that 10 mM acetic acid could depress the bitterness of 1 mM quinine hydrochloride to one hundredth.

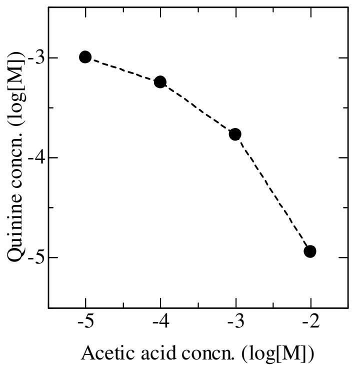

Fig. 3: Suppression of quinine HCl bitterness by acetic acid.

Bitterness of sodium picrate

Another type of bitter substance is sodium picrate, which has negative charge. The response of the sensor to it is shown in Fig. 4. This acid caused marked potential change in the positively charged membranes. At concentratin of 0.1 and 1.0 mM, the potential of N and T membranes changed approximately 200 mV, which is significantly larger than the theoretical value of 60 mV. It suggests that not only the shielding effect but also adsorption play an important role.Effects of food constituents such as sucrose (100 mM), NaCl (100 mM), MSG (10 mM) and HCl (1 mM) on the response of the sensor to sodium picrate were measured. The response of the positively charged membranes in the presence of NaCl and HCl were shown in Fig. 5. Contrary to quinine hydrochloride, HCl scarcely depressed the response to sodium picrate. NaCl was more effective than HCl.

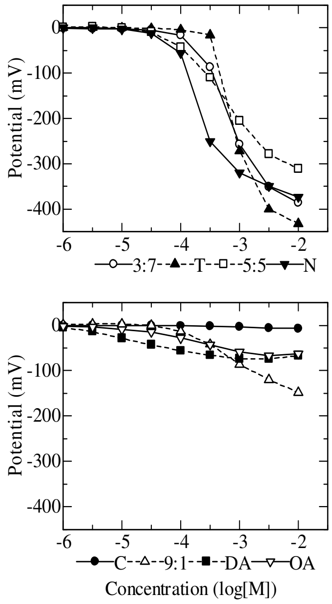

Fig. 4: Response of the sensor to sodium picrate.

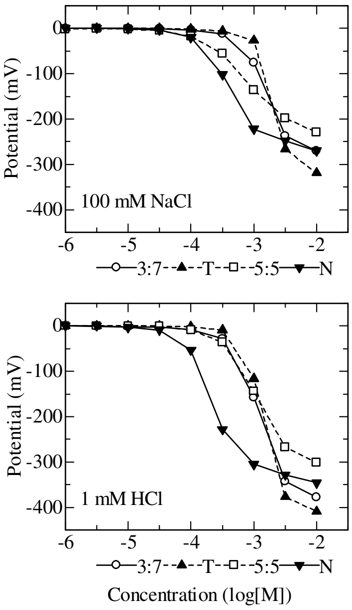

Fig. 5: Effect of NaCl and HCl on the response of the sensor to sodium picrate

Subsequently, influences of many salts of inorganic acid and organic acids were investigated. Salts of fatty acids depressed the response of the sensor to sodium picrate, especially at long chain. Figure 6 depicts the effect of 10 mM sodium salts of fatty acids on the potential of membrane T. As the carbon number of fatty acids, namely the hydrophobicity increased, the suppression of bitterness also increased. The negative part of fatty acid may adsorb the positively charged membrane, and interfere the interaction with sodium picrate.

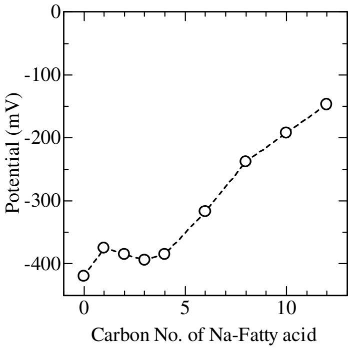

Fig.6: Suppression of the sensor to sodium picrate by sodium salts of fatty acids.

Conclusion

In this study, it was shown that the bitterness of quinine hydrochloride and sodium picrate could be suppressed by sour substances and salts of acids, respectively. The suppression was quantified using the taste sensor. Consequently, the taste sensor is expected to provide a new quantitative method to measure the strength of bitterness of foods and drugs in place of sensory evaluation.

References

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