Quercetin Glucosides are Hydrolyzed to Quercetin in Human Oral Cavity to Participate in Peroxidase-Dependent Scavenging of Hydrogen Peroxide

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It has been reported that consuming food which contains flavonols is related to the decrease in risks to arteriosclerosis and cancer. One objective of this study was to elucidate the metabolism of quercetin and the glucosides (quercetin 3,4'-diglucoside and quercetin 4'-glucoside) present in onion soup, in the oral cavity. Not only quercetin glucosides but also quercetin were found in whole saliva which was collected 15 min after eating onion soup. Quercetin seemed to be formed by deglucosidation of the glucosides. The concentrations of the flavonols were much higher in sediments than in supernatants of the saliva suggesting that the flavonols bound to components of the sediments like detached epithelial cells. Concentrations of quercetin and the glucosides in the oral cavity decreased as a function of time after the intake. The decreases were mainly due to the washing away from this cavity by saliva. In addition, deglucosidation of quercetin glucosides to quercetin was also assumed to contribute to the decrease in the glucosides and oxidation of quercetin by peroxidase (POX) in saliva to the decrease in quercetin. Based on the data that quercetin was oxidized by POX in saliva in the presence and absence of thiocyanate, it is suggested that quercetin as well as thiocyanate can be a substrate for POX in saliva to scavenge H₂O₂ in oral cavity.

Keywords: H₂O₂-scavenging, metabolism of quercetin and the glucoside, onion (Allium cepa), oral cavity, peroxidase in saliva

Polyphenols including flavonol quercetin have antioxidative activities (Rice-Evans & Miller, 1997; Terao & Piskula, 1997). The activities have been discussed in relation to the decrease in risks to arteriosclerosis and cancer (Carrol et al., 1997; Hertog & Katan, 1997). Onion bulbs contain large amounts of quercetin 4'-glucoside (Q4'G) and quercetin 3,4'-diglucoside (Q3,4'G), but a small amount of quercetin (Hirota et al., 1998, 1999, Tsushima & Suzuki, 1996). The glucosides are stable during boiling (Hirota et al., 1998) and frying (Price et al., 1997). Hollman et al. (1996, 1999) measured concentrations of quercetin in blood plasma after ingesting fried onions and stated that not only quercetin but also quercetin glucosides are possibly absorbed at intestine. Although flavonols are normally ingested through the mouth as components of foodstuffs, there are no reports on the metabolism of flavonols in the oral cavity as long as the authors know. When foods are ingested, they are normally chewed, allowing them to stay in the oral cavity for a while. During chewing, flavonols are dissolved in saliva and the dissolved flavonols may bind to epithelial tissues of the oral cavity. Since bacteria live in the oral cavity, the flavonol glucosides can be hydrolyzed to the aglycones by glucosidases excreted from the bacteria (Nakamura & Slots, 1983; Tenovuo, 1998). If H₂O₂ is present in saliva or formed in the oral cavity, flavonols may be oxidized by peroxidase (POX) in saliva because the POX can oxidize organic compounds as well as thiocyanate (Tenovuo, 1998). Salivary POX and myeloperoxidase are found in saliva (Tenovuo, 1998). H₂O₂ can be generated by bacteria (Thomas & Pera, 1983) and leukocytes (Yamamoto et al., 1991) in the oral cavity.

In this study, we selected onion bulbs as a food material to measure concentrations of flavonols in the oral cavity after being intaken as soup, because onion is a common foodstuff and because flavonols of onion bulbs, which are rather stable during boiling, are dissolved in boiling water (Hirota et al., 1998). One objective of the present study was the measurement of changes in the concentrations of quercetin, Q4'G and Q3,4'G in saliva after eating onion soup. The other objective was to elucidate whether quercetin can donate electrons to POX in saliva in the presence of H₂O₂. By comparing the concentrations among the flavonols in saliva and from oxidation of quercetin by POX in saliva, we discuss metabolism of quercetin and its glucosides and possible functions of the flavonols in the oral cavity.

Materials and Methods

Reagents Quercetin and catalase [I] were obtained from Wako Pure Chem. (Osaka) and Boehringer Mannheim (Germany), respectively. Q4'G and Q3,4'G were prepared by thin-layer chromatography (silica gel) as reported previously (Hirota et al., 1998).

Plant materials and preparation of onion soup Onion bulbs (Allium cepa L., cv. kamui) were obtained from Takii (Kyoto). Fifty grams of the scales was added to 200 ml of water and boiled. Boiling was continued until the volume of the cooking water was reduced to 200 ml (about 20 min). The boiled onion scales were homogenized in the cooking water for 0.5 min using a food processor (MK-K47, National, Kobe) by adding 1 g of NaCl. One milliliter of the homogenate was withdrawn and was mixed with 4 ml of methanol. After centrifugation at 5000×g for 5 min, the supernatant was dried under a stream of

Abbreviations: PBS solution, phosphate buffered saline solution; Q4'G, quercetin 4'-glucoside; Q3,4'G, quercetin 3,4'-diglucoside; POX, peroxidase.
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N₂ gas and dissolved in 0.1 ml of a mixture of methanol and 25 mM KH₂PO₄ (1:1, v/v). One microliter of this solution was applied to an HPLC column to quantify quercetin and the glucosides (see below). The amounts of quercetin, Q₄G and Q₃,₄G were 1.8 ± 1, 293 ± 94 and 138 ± 37 nmol ml⁻¹ of onion soup (n = 12), respectively.

Taking onion soup and extraction of flavonol from saliva Flavonols in the oral cavity after the ingestion of onion soup were measured using whole saliva collected from two of the authors (a male and a female). This experiment was repeated three times for each person. Since the results were not significantly different between the two persons, results were expressed as means ± SEs (n = 6). On the morning of an experimental day, no vegetable or fruit was eaten at breakfast. At lunch time (about 12.00 am), onion soup (199 ml) prepared as described above was eaten over a period of about 20 min. Immediately after lunch, teeth were brushed using toothpaste and then whole saliva (1.5 ml) was collected by chewing parafilm. No other foods were consumed, but water was taken after lunch. The collected saliva was centrifuged at 20,000 × g for 5 min at 4˚C. To extract flavonols, 1 ml of the supernatants was mixed with 4 ml of methanol, and 1 ml of 80% methanol was added to the sediment of which the volume was about 0.02 ml per ml of saliva. After removing insoluble components by centrifugation (5000 × g for 5 min, 15˚C), the methanol solutions were dried under a stream of N₂ gas at about 40˚C and the residue was dissolved in 0.1 ml of a mixture of methanol and 25 mM KH₂PO₄ (1:1, v/v). Fifty microliters of the methanol solution was applied to an HPLC column to determine concentrations of quercetin and the glucosides in saliva (see below).

HPLC analysis HPLC was performed using a Shim-pack CLC-ODS column (15 cm × 0.6 cm i.d.) (Shimadzu, Kyoto) combined with a spectrophotometric detector with a photodiode array (SPD M10A, Shimadzu). A mixture of methanol and 25 mM KH₂PO₄ (1:1, v/v) was used as a mobile phase. Quercetin and the glucosides were detected at 360 nm and the amounts were determined from areas under the peaks. Components, of which retention times and absorption spectra were identical with those of Q₃,₄G, Q₄G and quercetin, were found in saliva. These flavonols have been reported to be contained in onion bulbs and the soup (Hirota et al. 1998).

Enzymatic activities Whole saliva (5–10 ml) was collected by chewing parafilm at about 11 am. This saliva was used to measure deglucosidation of Q₄G and Q₃,₄G and to study the effects of catalase on oxidation of quercetin. The reaction mixture for deglucosidation contained 1.0 ml of saliva and 5–10 µl of 80% methanol extracts of onion scales, depending on the concentrations of flavonols of the extracts. Initial average concentrations of Q₄G, Q₃,₄G and quercetin of the reaction mixture were about 1.7, 1.8 and 0.03 nmol ml⁻¹, respectively. After incubation for defined periods, the reaction mixture was centrifuged at 20,000 × g for 5 min. Four milliliters of methanol was added to the supernatant and 1 ml of 80% methanol was added to the sediment. Insoluble components were removed by centrifugation, and the methanol solution was dried under a stream of N₂ gas. The residue was dissolved in a mixture of methanol and 25 mM KH₂PO₄ (1:1, v/v) to quantify quercetin, Q₃,₄G and Q₄G by HPLC as described above. The reaction mixture to measure effects of catalase on quercetin oxidation contained 0.5 ml of whole saliva and 10 µM quercetin with and without 1300 units of catalase. After incubation for defined periods, 2 ml of methanol was added to extract quercetin, and the solution was then centrifuged at 3000 × g for 5 min. The supernatant was dried with a rotary evaporator and the residue was dissolved in a mixture of methanol and 25 mM KH₂PO₄ (3:2, v/v) to quantify quercetin by HPLC. This mixture was also used as a mobile phase for the quantification by HPLC.

To study POX-dependent oxidation of quercetin, whole saliva (5 ml) was centrifuged at 20,000 × g for 5 min and dialyzed against 2 l of PBS solution, which contained 8.0 g NaCl, 0.2 g KCl, 1.15 g Na₂PO₄, 0.2 g KH₂PO₄, 0.1 g CaCl₂ and 0.1 g MgCl₂·6H₂O per liter; this was done for 12 h with gentle stirring at 4˚C. The dialyzed saliva was centrifuged at 20,000 × g for 5 min and used to measure H₂O₂-dependent oxidation of quercetin. The reaction mixture (1 ml) contained 10 or 50 µM quercetin, 0.1 ml of dialyzed saliva, 2–100 µM H₂O₂ and 0.9 ml of PBS solution. Since absorption at 380 nm of quercetin is decreased by POX-dependent oxidation (Takahama & Hirota, 2000), we measured the oxidation of quercetin by POX in saliva at 380 nm. The difference in absorption coefficients between quercetin and the oxidation products was estimated by adding 10 µM H₂O₂ to a reaction mixture that contained 50 µM quercetin and 0.1 µg ml⁻¹ of horseradish peroxidase (type II, Sigma). The value was 18 mM⁻¹ cm⁻¹. Since POX in saliva can evolve molecular oxygen in the presence of H₂O₂ (Nishio et al., 1996), the effects of quercetin on POX-dependent oxygen evolution were also measured using an oxygen electrode from Rank Brothers (Cambridge, UK) at 37˚C. The reaction mixture (2 ml) contained 0.2 ml of dialyzed saliva, 1 mM NaSCN and 1.8 ml of PBS solution. Reactions were started by adding known amounts of H₂O₂.

Whole saliva from which the cellular components had been removed by centrifugation (3000 × g, 5 min) was also used to measure H₂O₂-dependent oxidation of quercetin. The reaction mixture contained 1 ml of centrifuged saliva, 10–50 µM quercetin and 10 or 100 µM H₂O₂.

Results and Discussion Changes in levels of quercetin and the glucosides It is known that saliva collected in this study is constituted of saliva secreted from salivary glands, cells detached from epithelial tissues of the oral cavity and small amounts of leukocytes (al-Essa et al., 1994, Yamamoto et al., 1991). The saliva used in this study contained detached epithelial cells as the main cell components. If flavonols are found in saliva, they are derived from saliva and/or epithelial tissues of the oral cavity. The former is deduced from the data that concentration of salicylic acid in saliva is related to that of the chemical in plasma (Graham & Rowland, 1972); the latter is deduced from the report that flavonols bind to erythrocytes (Sorata et al., 1984).

Figure 1 shows changes in concentrations of quercetin, Q₄G and Q₃,₄G in saliva after ingesting the onion soup. Before taking the soup, concentrations of quercetin and the glucosides in saliva were low in both the supernatant and the sediment (time zero in Fig. 1). The sediment was mainly constituted of detached epithelial cells. Concentrations of the flavonols of the supernatant and the sediment were high 15 min after the intake. Since whole saliva was collected after washing of the oral cavity by tooth-brushing, this result indicates that not all the quercetin glucosides
in the onion soup are removed from the oral cavity by the washing. Flavonols may bind to epithelial tissues of the cavity and the binding flavonols are dissolved in saliva during the collection.

Concentrations of quercetin, Q4¢G and Q3,4¢G of the supernatant and the sediment were gradually decreased after the intake of onion soup (Fig. 1). The concentrations did not decrease to below the detectable point for more than 4 h. The decrease may be mainly due to washing away of the flavonols from the oral cavity by saliva, although other reasons like deglucosidation and oxidation are also considered (see below). In addition, gradual decreases in salivary concentrations of flavonols also suggest that even if flavonols are secreted as salivary components, the amounts are not large. Flavonol in plasma attains a maximal level 2–3 h after the intake of foods (Hollman & Katan, 1997).

Ratios of Q4¢G to Q3,4¢G in concentration were about 4.5 in the supernatants and about 6.7 in the sediment of saliva 15 min after the intake of onion soup (Fig. 1). The concentrations did not decrease to below the detectable point for more than 4 h. The decrease may be mainly due to washing away of the flavonols from the oral cavity by saliva, although other reasons like deglucosidation and oxidation are also considered (see below). In addition, gradual decreases in salivary concentrations of flavonols also suggest that even if flavonols are secreted as salivary components, the amounts are not large. Flavonol in plasma attains a maximal level 2–3 h after the intake of foods (Hollman & Katan, 1997).

Ratios of Q4¢G to Q3,4¢G in concentration were about 4.5 in the supernatants and about 6.7 in the sediment of saliva 15 min after the intake of onion soup (Fig. 1), whereas the ratio in the soup itself was about 2. The higher ratios in saliva may be due to more rapid washing away of Q3,4¢G than Q4¢G from the oral cavity. If this is true, the difference in binding of the two glucosides to epithelial tissues may contribute to the difference in the ratios of Q4¢G to Q3,4¢G between saliva and the soup. To examine this, methanol extracts of onion scales were mixed with whole saliva, and then concentrations of Q4¢G and Q3,4¢G of the supernatant and the sediment were measured (Fig. 2). Ratios of Q4¢G to Q3,4¢G in concentration immediately after the mixing (at time zero) were higher in the sediments (about 2) than the supernatants (about 1), indicating that Q4¢G binds to detached epithelial cells more easily than Q3,4¢G. From this result, it is deduced that the high ratios of Q4¢G to Q3,4¢G in Fig. 1 are due to the difference in binding between the two glucosides to epithelial tissues. Difference in hydrophobicity between the two glucosides may contribute to the difference in binding. It has been reported that quercetin binds to erythrocytes more easily than rutin (quercetin 3-rutinoside) (Sorata et al., 1984). The other possible explanation of the higher ratios is faster metabolism of Q3,4¢G than of Q4¢G in the oral cavity. This possibility can be excluded from the result in Fig. 2 in which concentrations of Q3,4¢G were decreased more slowly than those of Q4¢G when methanol extracts of onion bulbs were incubated with whole saliva.

Concentration ratios of quercetin to Q4¢G plus Q3,4¢G were about 0.3 and 2 in the supernatant and the sediment, respectively, 15 min after the intake (Fig. 1), whereas those in onion soup were less than 0.01. Two possible reasons are considered for the higher ratios in saliva than in the soup. One is the easier binding of quercetin to epithelial tissues of the oral cavity than the glucosides due to the difference in hydrophobicity between quercetin and the glucosides. The other is hydrolysis of quercetin glucosides to quercetin in this cavity.

To examine the possibilities, changes in concentrations of
quercetin and the glucosides were measured after the addition of methanol extracts of onion scales to whole saliva (Fig. 2). Concentration ratios of quercetin to Q4¢G plus Q3,4¢G were significantly higher in the sediment (about 0.08) than the supernatant (about 0.01) of saliva immediately after the addition of the methanol extracts (at time zero in Fig. 2). This result indicates that quercetin can bind to components of the sediment more easily than the glucosides. Concentrations of Q4¢G and Q3,4¢G were decreased during incubation in both the supernatant and the sediment (Fig. 2), suggesting that not only free but also binding quercetin glucosides are hydrolyzed. The decrease in Q4¢G was faster than that in Q3,4¢G indicating that Q4¢G was more readily metabolized than Q3,4¢G. No significant changes in concentrations of quercetin were observed in the supernatant, but in the sediment, the levels increased and attained a maximal concentration during decrease of the concentrations of quercetin glucosides. This result indicates that quercetin formed by the deglucosidation binds to components of the sediment. If quercetin is formed in the oral cavity during the ingestion of onion soup, the aglycone may bind to epithelial tissues. The deglucosidation can be catalyzed by glucosidases secreted from bacteria in the oral cavity (Makinen, 1998; Nakamura & Slots, 1983).

Concentrations of quercetin in the oral cavity decreased gradually from the maximal levels after the intake of onion soup (Fig. 1). Two possibilities are considered for the decrease: one is the washing away from the oral cavity by saliva and the other is degradation. The latter is deduced from the data in Fig. 2 that levels of quercetin attained maximal levels while levels Q4¢G were decreasing. To examine the degradation of quercetin in the oral cavity, changes in concentrations of quercetin were measured during incubation of whole saliva which was prepared 15 min after ingesting the onion soup (Fig. 3). The level of quercetin was initially somewhat increased, and then decreased, whereas the levels of Q4¢G and Q3,4¢G were decreased rapidly and very slowly, respectively. These results support the formation of quercetin from the glucosides as indicated in Fig. 2 and the degradation of quercetin in whole saliva. One possible degradation reaction is oxidation, and to examine this, the effects of catalase on oxidation of quercetin were studied (Table 1). Although the variations were large, catalase inhibited oxidation of quercetin suggesting that quercetin is oxidized by not only H2O2-dependent but also H2O2-independent reactions. The minimal effects of catalase may be due to slow rates of H2O2 formation. The H2O2-dependent oxidation of quercetin may be catalyzed by POX in saliva. H2O2 can be formed by autooxidation of quercetin and by leukocytes and bacteria in saliva. This autooxidation is possible because pH of saliva is between 7.4 and 7.8 (Dodds & Johnson, 1993). Further studies are required to elucidate the H2O2-independent oxidation.

Oxidation of quercetin by POX The concentration of quercetin in the sediment of saliva reached 5–10 μM (Fig. 1). From this result, we can assume that concentrations of quercetin around epithelial tissues of the oral cavity may be increased to 5–

![Fig. 3. Oxidative degradation of quercetin in saliva.](image)

Saliva prepared 15 min after ingestion of onion soup was incubated for various periods. Quercetin and the glucosides were measured using whole saliva without separating into supernatant and sediment. Open circles, Q3,4¢G; closed circles, Q4¢G; squares, quercetin. Values are means±SEs (n=6).

![Fig. 4. Oxidation of quercetin by dialyzed saliva.](image)

The reaction mixture (1 ml) contained 0.1 ml of dialyzed saliva and 0.9 ml of PBS solution. Upper panel, absorption spectrum of 50 μM quercetin; lower panel, difference spectrum of quercetin and the oxidation products. Immediately after memorization of an absorption spectrum of quercetin, 1 mM H2O2 was added and a difference spectrum was recorded. Scanning speed was 120 nm min⁻¹.

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**Table 1.** Effects of catalase on the decreases in levels of quercetin in whole saliva.

<table>
<thead>
<tr>
<th>Incubation time (min)</th>
<th>0</th>
<th>30</th>
<th>60*</th>
</tr>
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<tbody>
<tr>
<td>−Catalase</td>
<td>100</td>
<td>61±14</td>
<td>26±14</td>
</tr>
<tr>
<td>+Catalase (1300 unit ml⁻¹)</td>
<td>100</td>
<td>74±14</td>
<td>50±15</td>
</tr>
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Initial concentration of quercetin was 10 μM.

*Significant difference at level of 5% (Student’s t-test between −catalase and +catalase, n=4)
10 μM after ingestion of onion soup, because the sediment was mainly constituted of detached epithelial cells. If POX in saliva binds epithelial cells (Makinen, 1998), quercetin can be present in the concentration range around the bound POX. We measured POX-dependent oxidation of quercetin by dialyzed saliva to elucidate the possible function of quercetin in the oral cavity. Q4’G and Q3,4’G were not used as substrates for POX in this study because the glucosides were oxidized much more slowly by POX than quercetin (Hirota et al., 1998). When H2O2 was added to dialyzed saliva in the presence of 50 μM quercetin, quercetin was oxidized and the oxidation was observed as a decrease and an increase in absorbance at about 380 and 320 nm, respectively (Fig. 4, lower). Such changes in the absorption spectrum on oxidation of quercetin have been reported and some of the oxidation products have been identified (Hösel & Barz, 1972; Schreier & Miller, 1985; Takahama & Hirota, 2000). In the oxidation products, 3,4-dihydroxybenzoic acid, 2,4,6-trihydroxyphenylglyoxallic acid and 2,3,5,7,3’,4’-hexahydroxyflavanone are included. The absorption increase around 320 nm is due to the formation of the flavanone. In the following, oxidation of quercetin was measured by absorption decrease at 380 nm.

Figure 5 shows typical time courses of oxidation of 10 μM quercetin. When 5 (traces 1, solid line) or 50 μM (traces 2, solid line) of H2O2 was added, quercetin was rapidly oxidized. Since thiocyanate is a normal component of saliva and is a substrate of POX in saliva, the effects of thiocyanate on the oxidation of quercetin were studied. The oxidation of quercetin was inhibited by 1 mM NaSCN which was a normal concentration in saliva. Degree of the inhibition was greater at 5 than at 50 μM H2O2. The oxidation of quercetin by 1 mM H2O2 was slow and the oxidation was not inhibited by 1 mM NaSCN. Salivary POX, which was partially purified from human saliva by ammonium sulfate precipitation, ion exchange chromatography using CM cellulose and gel filtration using Sephacryl S-200 (Pharmacia Biotech.), also oxidized quercetin in the presence of H2O2 (data not shown).

Figure 6 shows the effects of H2O2 concentration on the oxidation of quercetin (10 and 50 μM) by dialyzed saliva. The rate increased as the concentration of H2O2 was increased from 2 to 50 μM. The oxidation of quercetin was inhibited by 1 mM NaSCN, and the degree of inhibition became smaller as the concentration of H2O2 was increased to 50 μM. Km values for H2O2 were estimated in the concentration range of H2O2 from 2 to 50 μM by Lineweaver-Burk plots. The values were about 4 μM in the presence of 10 μM quercetin and about 10 μM in the presence of 50 μM quercetin. The inhibition of quercetin oxidation by 1 mM NaN SCN was competitive. These results suggest that POX in saliva can use not only SCN− but also quercetin as a substrate to scavenge H2O2, and that the H2O2-scavenging function of the POX/quercetin system becomes more important as the concentration of H2O2 is increased from 2 to 50 μM. According to a paper by Thomas and Pera (1983), local concentrations of H2O2 in the oral cavity can be increased to 50–500 μM when H2O2 is generated by Streptococcus mutans. Concentrations of H2O2 in saliva may also be increased during the chewing of foods, because foodstuffs sometimes contain high concentrations of H2O2 (Tsujj et al., 1990). Leukocytes of saliva may also participate in the formation of H2O2 (Yamamoto et al., 1991).

When the concentration of H2O2 was increased from 0.1 to 1 mM, the rate of oxidation of quercetin was decreased (Fig. 6). No clear effect of 1 mM NaSCN was observed for the oxidation in the concentration range of H2O2, although 1 mM NaSCN was sometimes stimulative at 1 mM H2O2 (Fig. 5). In this concentrate-
tion range of H₂O₂, salivary POX-dependent oxygen evolution is observed (Nishioka et al., 1996). We, therefore, measured the effects of quercetin on the oxygen evolution, which was not inhibited by 10 mM aminotriazol, to elucidate the mechanism of the slowing down of quercetin oxidation. Rates of oxygen evolution were increased as a function of H₂O₂ concentration (Fig. 7). Quercetin (50 μM) inhibited initial rates of the oxygen evolution by about 40% in the presence of 1 mM H₂O₂, and the inhibition was nearly saturated at that concentration of quercetin. Degree of the inhibition by quercetin depended on the concentration of H₂O₂; the degree was high at lower concentrations of H₂O₂ (Fig. 7). The inhibition by 50 μM quercetin was competitive when oxygen evolution was measured in the H₂O₂ concentration range from 0.1 to 1 mM. Oxygen evolution catalyzed by salivary POX, which was partially purified from saliva as described above, was also inhibited by quercetin and this inhibition was also competitive. Since salivary POX-dependent oxygen evolution is disproportionation of H₂O₂ (Nishioka et al., 1996), these results indicate that quercetin can compete with H₂O₂ for compound I of salivary POX.

Figure 8 (upper panel) shows a typical time course of H₂O₂-dependent oxidation of quercetin in centrifuged saliva; the absorption increase when quercetin was added was canceled out. With the addition of 10 and 100 μM H₂O₂, rapid absorption decreases were observed. The absorption decreases were dependent on the concentration of quercetin (Fig. 7, lower panel). From this result, it is deduced that quercetin can also be an electron donor to POX in saliva or in the oral cavity when H₂O₂ is present.

Conclusions

From the detection of flavonols (quercetin, Q4¢G and Q3,4¢G) in saliva collected after ingestion of onion soup and washing the oral cavity, it is deduced that the flavonols of the soup bind to epithelial tissues of the cavity and that the binding flavonols are released into the saliva. The binding was dependent on hydrophobicity of the flavonols. Quercetin glucosides seemed to be hydrolyzed to quercetin in the oral cavity during and after ingestion of onion soup. The deglucosidation is deduced from the data that quercetin was formed from Q4¢G and Q3,4¢G in saliva. Quercetin was oxidized by POX in saliva in the presence and absence of thiocyanate in dialyzed saliva, and was also oxidized in saliva when H₂O₂ was present. These results indicate that quercetin can donate electrons to POX in saliva in the oral cavity to scavenge H₂O₂. Further studies are required to elucidate relative contribution of salivary POX and myeloperoxidase to oxidation of quercetin as saliva contains both enzymes.

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