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Effect of β-Cyclodextrin on the Taste Quality of Neohesperidin Dihydrochalcone

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Abstract

Neohesperidin dihydrochalcone(NHDC) is an intense sweetener with lingering aftertaste, which limits NHDC to use as a sweetener in food products. This study was conducted to examine the changes of taste quality of NHDC when using β-cyclodextrin(β-CD) as a taste modifier. A series of β-CD(0.01%, 0.03%, 0.1%, 0.176%) was added to NHDC solution(100ppm) and the taste quality was evaluated by magnitude estimation. It was found that β-CD produced a significant effect on the reduction of aftertaste of NHDC($p<0.01$) and sweetness as well.($p<0.001$). Linear regression(log mean magnitude estimate versus β-CD concentration) analysis showed that the intensity of sweetness($n=-0.31$) decreased more rapidly than that of aftertaste($n=-0.17$). This result suggests the possibility that β-CD may form inclusion complex with NHDC, so that the hydrophobic portion is encapsulated in the cavity of β-CD and the carbohydrate moiety is oriented to the outside of the cavity. Or it may be that β-CD competes with the NHDC molecule for binding to the taste receptor, resulting in reduced perceived intensity.

Key words: *neohesperidin dihydrochalcone, β-cyclodextrin, taste modifier, magnitude estimation, inclusion complex*

INTRODUCTION

Neohesperidin dihydrochalcone(NHDC) is an intense sweetener, possessing sweetening power 340 times higher than that of sucrose in 8.5% solution(1). Although NHDC is intensely sweet, other temporal properties such as slow onset and licorice-like lingering aftertaste are potent, which makes it of potential use in only a limited number of products, e.g., chewing gums, toothpastes and mouthwashes(2,3).

Many sweet compounds have a taste with slow onset time or with a lingering aftertaste. Hypotheses have been proposed to explain the temporal properties of sweet compounds(4-6). According to DuBois et al.(5), it is suggested that the sweet taste sensation of non-sucrose like sweeteners such as NHDC follows a rapid diffusion of molecules to non-receptor binding sites close to the receptor protein. Secondary diffusion to a sweet taste receptor sites results in delayed taste response. Based on the Shallenberger theory of sweetness(7), it has been hypothesized that the strong binding of NHDC to the taste receptor may be associated with the presence of two glucophore units(AH/B units) within the molecule(4). Assuming that the strong binding of NHDC to its non receptor sites is a dominant factor in sweet persistence, it has been suggested that a taste modifier might prevent binding to sites other than the receptor, thus reducing the persistence of taste(6).

β-cyclodextrin(β-CD) was selected as a taste modifier, since this compound has been used in improving the taste of citrus juices by forming inclusion complexes with organic substrates(8-10). It is conceivable that inclusion complexes involving the hydrophobic aromatic parts of NHDC could be formed. If so, this could alter the taste property of NHDC by affecting the interaction between NHDC molecule and the receptor sites. Since no expreiments have been reported with respect to the effect of β-CD on the taste quality of NHDC, the objective of this study was to investigate the effect of β-CD on both the sweetness and aftertaste intensity of NHDC.

MATERIALS AND METHODS

Panelists

The taste panel consisted of eight female and two male subjects. All of them had previously participated in sensory experiments. Panelists were instructed to 'sip and spit' each solution and wait until a maximal intensity was reached. Eating an unsalted crackers between samples was necessary to remove aftertaste. Panelists were unaware of the purpose involved in the

study. Prior to actual experiments, panel members were trained to become familiar with the sensory properties of NHDC solutions. The order of presentation was randomized within each pair as well as across the panelists through the experiment. All sessions were held in either midmorning or midafternoon from Monday through Friday.

Test solution preparation

All solutions of NHDC(supplied by Sigma Co.) and NHDC+β-CD(Sigma Co.) were prepared with deionized water. Samples were presented in 1.25 oz. paper cups coded with random three digit numbers. Solutions were prepared 18 hour before testing and stirred for 6 hours and stored at room temperature.

Sensory evaluation

The threshold of β-CD was determined in an attempt to add β-CD at a level below the threshold to the NHDC solutions. β-CD solutions were evaluated by paired comparison following the guidelines of Guadagni et al.(11). Six different amounts of β-CD(0.05%, 0.1%, 0.25%, 1.0% and 2.0%) were dissolved in deionized water and compared for sweetness with the blank. The effect of β-CD on the taste quality of NHDC was evaluated by adding subthreshod levels of β-CD to NHDC. A series of increasing amounts of β-CD(0.01%, 0.03%, 0.1%, 0.176%) was added to NHDC(100ppm) and the taste quality was evaluated by magnitude estimation. Panelists were first presented with a reference(pure NHDC solution). They were asked to rate the maximal perceived aftertaste intensity of a series of NHDC+β-CD solutions relative to a reference value. Sweetness intensity was then determined in a similar fashion with the same solutions. A maximum of five compounds were tested against a reference solution per session with four replications. A sensory evaluation form is shown in Fig. 1.

Data analysis

Analysis of data was accomplished by means of SAS. Magnitude estimation values were converted to logarithms and expressed using the geometric mean. Linear regressions were peformed on the mean groups of sweet or aftertaste intensity data.

RESULTS AND DISCUSSION

The sensory data of the threshold determination of β-CD in water are shown in Table 1. It was found that β-CD did not have a distinguishable taste up to 0.25% compared to deionized water. Above 0.5%, the sweet taste of β-CD was obvious and at higher concentrations, some panelists described the taste as bitter. The effect of β-CD on the aftertaste and sweetness intensity of NHDC was observed. In Table 2 are the mean values of the estimates of aftertaste and sweetness

Taste Intensity Evaluation

Judge : _____ Date : _____

You will be receiving a series of cups containing stimulus solutions. Your task is to indicate intensities by assigning numbers which are proportional to their taste. Use the reference as your first sample. Roll the solution over your tongue for at least 5 seconds(until maximum intensity is perceived) before scoring. You may use any positive number, fraction or decimal other than zero. Rinse well between tasting. Eating crackers between samples will be necessary to remove aftertaste. Wait approximately 1~2 minutes between tasting. Retasting the reference solution is allowed if desired.

Sample code	Intensity of sweetness(aftertaste)	Notes(if any)

Fig. 1. Sensory evaluation form.

Table 1. Detectability of β-CD in water solution

β-CD(%)	n[1)]	No. of judgement indicating which sample is sweeter	
		β-CD	Water
0.05	24	10	14
0.1	22	12	10
0.25	22	11	11
0.5	22	19	3
1.0	22	21	1
2.0	22	22	0

[1)]Number of evaluation

Table 2. Relative taste intensities[1)] of NHDC+β-CD solutions

Compound	Magnitude estimate value		n[2)]
	Aftertaste	Sweetness	
100 ppm NHDC(Reference)	1.60±0.49	1.96±0.51	38
100 ppm NHDC+0.01% β-CD	1.33±0.30	1.43±0.14	38
100 ppm NHDC+0.03% β-CD	1.05±0.14	1.11±0.21	38
100 ppm NHDC+0.10% β-CD	0.87±0.14	0.70±0.11	38
100 ppm NHDC+0.176% β-CD	0.82±0.26	0.61±0.08	36

[1)]Normalized value [2)]Number of evaluation

intensity respectively, as a function of changing the β-CD concentration. It was observed that β-CD produced a significant effect on the reduction of aftertaste of NHDC($p<0.01$) and sweetness as well($p<0.001$). Plots showing equation parameters derived from a linear regression of the log mean magnitude estimate versus β-CD concentrations are shown in Fig. 2. This suggests that β-CD reduced the aftertaste and sweetness intensity by a power function with R^2 values greater than 0.98. The exponent(slope) value of sweetness is about

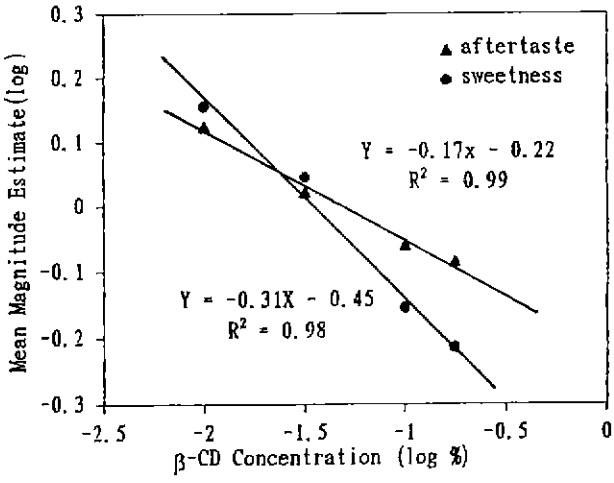

Fig. 2. Linear regression analysis of sweetness and aftertaste intensity of NHDC+β-CD solution.

half of that of aftertaste, indicating that the intensity of sweetness decreased more rapidly than that of aftertaste. Since all concentrations of β-CD are below the threshold of β-CD in water, its effectiveness in reducing the taste intensity is not related to a taste of its own. Within the range of concentrations studied for β-CD. both aftertaste and sweetness intensity decreased linearly. However, preliminary testing revealed that the overall perceived intensity of NHDC solutions containing 0.3% β-CD was judged to be greater than that of the mixture solution containing 0.176% β-CD (data not shown). This could be due to the fact that β-CD contributed an additional taste quality to the mixture and may have interfered with the perception of taste characteristics of NHDC solution. It was obvious that excessive addition of β-CD produced an objectionable sensory effect.

It is well accepted that the sweet taste receptor is a proteinaceous component embedded in a taste cell membrane. The receptor protein is believed to have a number of non-identical potential binding sites, with only a small portion of them being sweet taste receptor sites. The non-receptor sites are thought to act in unison to bind sweet molecules very strongly, and thus are responsible for the temporal properties of non-sucrose like sweeteners such as NHDC, thaumatin and other sweeteners. Based on this hypothesis, it is expected that there may exist taste modifiers which can bind to the non-receptor sites, thus changing the temporal taste properties of sweet compounds.

We used β-CD as a taste modifier. Ever since a number of studies revealed that oral consumption of CD is safe, the use of CD covers a wide range of applications in the food industry such as controlling flavor release, masking odors and tastes, stabilizing emulsions, controlling or masking color, etc(12). One such application is debittering of orange and grapefruit juices where a β-CD polymer is used to reduce the level of such bitter components as naringin and limonin(8-10). As we have seen, an attempt to suppress the aftertaste of NHDC, while maintaining the sweet taste was unsuccessful. When the aftertaste was masked, the sweetness was also masked, resulting in a total reduction of taste perception. This result suggests the possibility that β-CD may form inclusion complex with NHDC, so that the hydrophobic portion is encapsulated in the cavity of β-CD and the carbohydrate moiety is oriented to the outside of the cavity(Fig. 3).

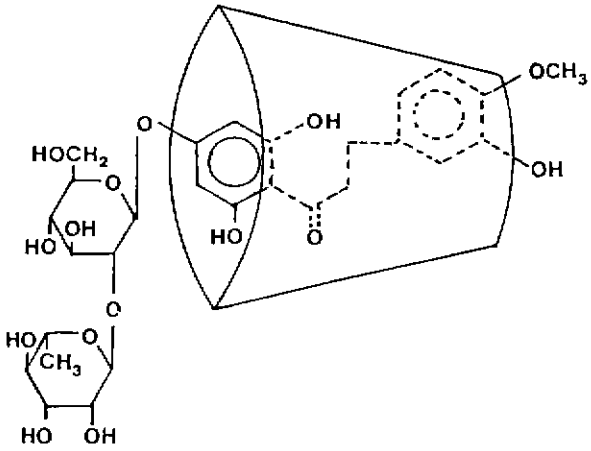

Fig. 3. β-CD inclusion complex formation of NHDC.

Therefore, the resulting complex is unsuitable to fit into the receptor. Or it may be that β-CD competes with the NHDC molecule for binding to the taste receptor, resulting in reduced perceived intensity. It is concluded that β-CD reduced both the aftertaste and sweetness of NHDC and that the sweet quality of the resulting mixture was inferior to that of NHDC alone.

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