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Original article

Effect of the bitterness of food on muscular activity and masticatory movement

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ABSTRACT

Purpose: The purpose of this study was to clarify the effect of the bitterness of food on muscular activity and masticatory movement.
Methods: Twenty healthy subjects were asked to chew a non-bitter gummy jelly and a bitter gummy jelly on their habitual chewing side. The masseter muscular activity and the movement of mandibular incisal point were recorded simultaneously. For all cycles excluding the first cycle, parameters representing the muscular activity (total integral value and integral value per cycle) and masticatory movement (path, rhythm, and stability) were calculated and compared between the two types of gummy jellies.
Results: The total integral value of masseter muscular activity during the chewing of bitter gummy jelly was significantly smaller than during the chewing of non-bitter gummy jelly, however, no definite trends in the integral value per cycle and the stability of movement were observed. The parameters representing the movement path tended to be small during the chewing of bitter gummy jelly than during the chewing of non-bitter gummy jelly. The masticatory width was significantly smaller during the chewing of bitter gummy jelly. The parameters representing the rhythm of movement were significantly longer during the chewing of bitter gummy jelly than during the chewing of non-bitter gummy jelly.
Conclusion: From these results it was suggested that the bitterness of food does not affect the integral value per cycle or the stability of the masticatory movement, but it does affect the movement path and rhythm, with narrowing of the path and slowing of the rhythm.

1. Introduction

Though mastication is maintained in a rhythmic pattern by a pattern generator in the brain stem, it is also affected by the nature of food [1]. Many studies have been carried out to investigate the effects of food size and hardness on masticatory movement. It has been reported that masticatory movements vary based on the nature of foods, and the amount and velocity of masticatory movement increase and the cycle time tends to be increased with increasing size or hardness of food [2–8].

The effects of taste on masticatory movement have not been thoroughly investigated [9–14]. To investigate the effects

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of taste on masticatory movement, focusing, for instance, on the effects of sweetness, the experiment would require substantial modifications of the components of the test foods. This would eventually obscure the aim of the experiment owing to the inevitable alterations in the composition of the test foods that would also cause changes in the hardness of the foods. The same will hold true for examining the effects of variations of the acid taste and salty taste, so that studies on the effects of variations of the taste on the masticatory movement still remain unclear.

In contrast, the effects of changes in bitterness can be investigated without modifying any other food characteristics because microquantities of quinine can be used as the source of bitter taste for testing. In this study, therefore, we analyzed the masseter muscular activity and movement of the mandibular incisor point while the healthy subjects chewed a non-bitter gummy jelly and a bitter gummy jelly, in order to clarify the effect of bitterness of food on masseter muscular activity and masticatory movement.

2. Materials and methods

2.1. *Ethics statement*

All the experimental procedures were approved by the Ethics Committee of Nippon Dental University (NDU-T2012-29). Informed consent was obtained from all subjects after they were provided with an explanation as to the general nature of the study.

2.2. *Subjects*

Twenty healthy subjects (12 males and 8 females, age range, 21–34 years; average age, 26.8 years) participated in this study. None of the subjects had any clinical abnormalities in the masticatory system. The following selection criteria were applied: no complaints about bite; possession of a full complement of teeth excluding the third molars; no major dental restorations; no history of orthodontic treatment.

2.3. *Test food*

A non-bitter gummy jelly and a quinine-containing bitter gummy jelly were used as the test foods. To determine the degree of bitterness in the test food, the three types of gummy jellies were prepared containing varying amounts of quinine, i.e., 482, 964, and 1446 μmol/kg, and the subjects were asked to chew the gummy jelly for 20 s. Each subject was then interviewed as to his/her subjective chewing sensation. The results of the interview revealed that 7 of the 20 subjects did not perceive a clear bitter taste while chewing the test food containing 482 μmol/kg quinine, while 8 of the 20 subjects perceived a strong bitter taste while chewing the test food containing 1446 μmol/kg quinine. With the test food containing 964 μmol/kg quinine, all 20 subjects reported that they perceived a bitter taste while chewing, but were able to continue chewing normally on the gummy jelly. Therefore, the gummy jelly containing 964 μmol/kg quinine was selected as the test food (Table 1). The texture parameters of the foods were measured at approximately 25 °C using a texture analyzer (TA.XT PLUS, EKO, Tokyo, Japan). Compressions were performed at a constant displacement rate of 1.0 mm/s and compression ratio of 67% of the original sample height. Ten samples were tested.

Table 1 – The size, weight and ingredients of the gummy jelly.

Size (mm)	φ14 × 8
Weight (g)	2
Ingredient (%w/w)	
Gelatin	8
Maltose	40
Solbitol	10
Glucose	5
Others (water)	37

2.4. *Recording method*

Subjects were asked to chew a non-bitter gummy jelly and a bitter gummy jelly on their habitual chewing side for 20 s. The masseter muscular activity was recorded using an electromyography (RM6000, Nihon Kohden, Tokyo, Japan) and the movement of the mandibular incisal point was recorded using a mandibular kinesiograph (MKG K6-I, Myotronics, Seattle, WA, USA) simultaneously using a data recorder (XR-5000, TEAC, Tokyo, Japan). One hour prior to testing subjects were asked not to eat or drink anything except water, not to smoke and not to brush their teeth. Before recording, the mouth was rinsed with deionized water. The recording was performed with the non-bitter gummy jelly chewing first and then the bitter gummy jelly chewing. A five-minutes interval between each chewing was set.

2.4.1. *Masseter muscular activity*

The parameters representing the masseter muscular activity were established. For masseter muscular activity, the analog signals from the data recorder were converted into digital signals at 2000 Hz (Fig. 1) and the total integral value and the integral value per cycle for all cycles excluding the first cycle were calculated. The movement is irregular and slow during the first cycle immediately after the beginning of mastication, because it involves transferring the food to the dental arches by the tongue. Therefore, the first cycle was excluded from the analysis in this study.

2.4.2. *Movement of the mandibular incisal point*

In regard to movement of the mandibular incisal point, the analog signals from the data recorder were converted into digital signals at 100 Hz (Fig. 1) and the parameters representing the path of movement, rhythm of movement, stability of path, and stability of rhythm for all cycles excluding the first cycle were calculated. The parameters were calculated as follows.

2.4.3. *Movement path and stability of movement path*

Using the maximum intercuspal position (MIP) of each cycle as the standard, coordinates for each cycle were determined by vertically dividing the opening and closing paths into 10 equally spaced sections in the frontal view. From these

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