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Research Article

Increasing Hardness of Pellet Gum in Cold Weather and Tooth Fracture

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Abstract

There have been anecdotal reports of tooth fractures while chewing pellet types of gum. The aim of the present study was to observe the change in compressive strength of pellet type gum according to storage temperature. Forty pieces each of ten kinds of pellet type gum were divided according to storage temperature into control (18°C) and experimental (-5°C) groups. Maximum compressive strengths were measured with a metal jig and a natural maxillary first molar as the antagonists. The values were compared using independent t-tests. There were significant differences in maximum compressive strength between the experimental and control groups for all brands of pellet gum. A comparison between the jig and the tooth antagonists revealed that the compressive strength recorded by the tooth was generally higher. Pellet type gum stored in the cold environment showed increased compressive strength, therefore caution should be exercised when chewing gum stored at cold temperatures.

Keywords: Chewing gum; Hardness; Tooth fracture; Cold weather

Introduction

Most people chew gum and the child group sometimes love to. Why do people chew gum? The answer might be somewhat different from individual to individual. Some people like the sweet flavor, others like the freshness and still others consider it a substitute for brushing their teeth when they are busy, even though they should not. It could also just be a long-standing cultural habit.

Several beneficial effects of chewing gum with specific ingredients have been reported. For example, the effects on dental caries have been studied extensively. The use of sugar-free chewing gum has been associated with oral health benefits [1-3]. In a systematic review by Deshpande and Jadad [4], the use of xylitol, xylitol-sorbitol blend and sorbitol chewing gum products were consistently associated with a reduction in caries.

Chewing gum has existed in various forms since the Neolithic period, 5,000 years ago. Modern chewing gum was developed in the 1860s and was originally made of chicle, which is a natural type of latex. By the 1960s, chicle was replaced by synthetic rubber, which is cheaper to manufacture [5]. Currently, various types of chewing gum are available on the market. Stick and pellet type gum are the most popular among them.

Pellet type gum is usually covered by a hard coating under a spray drier during the manufacturing process. The coating may be a homogeneous material built up of layers of coating syrup [6]. There have been frequent anecdotal reports of tooth fractures as a result of chewing pellet type gum, although there is not official documentation. Generally, gum is not thought to be hard enough to break teeth; however, it can become quite hard when stored in cold environments.

Until now, there have been no studies on the hardness of pellet type chewing gum in different temperature ranges. The present study investigates the compressive strength of pellet type gum from various manufacturers stored at different ambient temperatures of 18°C and -5°C. The aim of the present study was to observe changes in the compressive strength of pellet type gum according to storage temperature.

Materials and Methods

Forty pieces each of the following ten kinds of pellet type gum were tested in the present study: Dentine Ice (Kraft Foods Global, Northfield, IL, USA), Dentine Fire (Kraft Foods Global, Northfield, IL, USA), Eclipse (William Wrigley Jr. Company, Chicago, IL, USA), Orbit White (William Wrigley Jr. Company, Chicago, IL, USA), Trident White (Kraft Foods Global, Northfield, IL, USA), Trident Vitality Balance (Kraft Foods Global, Northfield, IL, USA), Trident Vitality Awaken (Kraft Foods Global, Northfield, IL, USA), Trident Splash (Kraft Foods Global, Northfield, IL, USA), Trident White Peppermint (Kraft Foods Global, Northfield, IL, USA), Xylitol original (Lotte, Seoul Korea). All of these types of gum are readily available in the United States and Korea.

Prior to the experiments, pieces of gum were selected if they were intact and lacked cracks or fractures in their surface. The gum was randomly allocated into two groups according to the storage temperature: the normal (control) and cool (test) groups. Twenty pieces were allocated per group. Gum in the control group was stored at an ambient temperature of 18°C and 70% humidity. Gum in the experimental group was stored in a refrigerator at -5°C and 70% humidity for a day prior to compressive load testing.

Following storage, all of the specimens were stabilized against a testing metal jig and subjected to a compressive load at a cross head speed of 1 mm/min with an universal electromechanical testing machine (Instron 4465, Norwood, MA, USA). This device provided the change in applied compressive strength (N) divided by the

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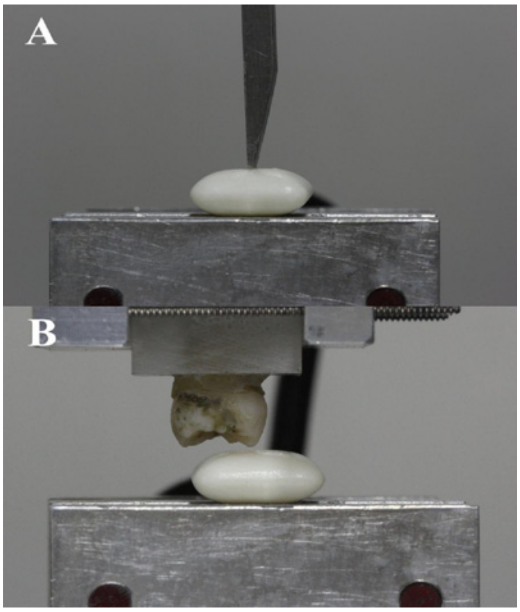

Figure 1: Used antagonists. (A): A metal jig. (B); A natural tooth, maxillary molar.

Table 1: Average maximum compressive strength (SD) in Newton when the metal jig was used as an antagonist.

Gum*	Room temperature (18°C)	Cold temperature (-5°C)
Dentine Ice*	37.61 (2.75)	80.05 (4.23)
Dentine Fire*	38.99 (2.52)	64.99 (4.02)
Eclipse*	33.97 (2.87)	91.00 (8.13)
Orbit White*	39.42 (2.39)	97.25 (6.63)
Trident White*	40.37 (2.37)	76.77 (4.29)
Trident Vitality Balance*	23.63 (2.28)	76.18 (4.33)
Trident Vitality Awaken*	26.83 (1.52)	78.82 (3.24)
Trident Splash*	31.70 (3.02)	74.44 (4.24)
Trident White Peppermint*	31.45 (2.53)	71.57 (3.93)
Xylitol original*	17.93 (1.81)	35.84 (2.78)

*denotes statistically significant difference (P < .001).

specimen surface area in a time dependent manner, and the peak load was recorded as the compressive strength due to the viscoelastic properties of gum material. As an additional test, a natural tooth was used as the antagonist instead of the metal jig. The mesiolingual cusp of the tooth was positioned on the center of the pellet gum surface to simulate occlusal contact in order to mimic a real situation. The tooth was a visually intact maxillary molar extracted for periodontal reasons that was embedded in acrylic resin (Figure 1).

SPSS software (SPSS for Windows, version 12.0, Chicago, IL, USA) was used to calculate the means and standard deviations of all measurements, and independent t-tests were used to determine significant differences between test and control groups. Significance was set at the 0.05 level of confidence, but was also assessed at the 0.01 and 0.001 levels.

Results

The descriptive statistics and the comparisons are summarized in Table 1 and 2. There were some differences in the maximum compressive strength value according to the brand of gum in the experimental and control groups. However, the strength curves recorded according to time were generally similar and exhibited viscoelastic properties (Figure 2).

Table 2: Average maximum compressive strength (SD) in Newton when the natural tooth was used as an antagonist.

Gum*	Room temperature (18°C)	Cold temperature (-5°C)
Dentine Ice*	60.47 (5.58)	111.55 (7.31)
Dentine Fire*	42.49 (3.25)	79.16 (6.30)
Eclipse*	68.37 (4.34)	138.95 (10.21)
Orbit White*	75.87 (7.70)	149.88 (9.39)
Trident White*	67.26 (4.47)	117.91 (7.85)
Trident Vitality Balance*	41.87 (4.59)	109.33 (8.32)
Trident Vitality Awaken*	43.90 (6.05)	113.05 (7.15)
Trident Splash*	52.31 (6.38)	105.74 (6.89)
Trident White Peppermint*	50.10 (6.05)	94.28 (6.73)
Xylitol original*	32.48 (2.97)	60.18 (5.78)

*denotes statistically significant difference (P < .001).

Results of the independent t-tests showed that there were significant differences in maximum compressive strength between the experimental and control groups for all brands of pellet gum irrespective of antagonist used (P<.001). This finding indicates that storing pellet gum at cold temperatures significantly increases its compressive strength. In general, the maximum compressive strength when natural tooth was used as an antagonist is recorded higher for all brands of pellet gum.

Discussion

In the present study, we investigated changes in the compressive strength of several types of pellet gum according to storage temperature. The gum was stored at either 18°C or -5°C. These temperatures were chosen because the former is the general indoor temperature and the other is the temperature of a refrigerator. Our experiments revealed a statistically significant increase in the compressive strength of gum stored in the cold environment. The reason may be the contact area difference why the average maximum compressive strength is higher when the natural tooth was used. The natural tooth antagonist was considered to mimic the real situation more closely but not perfectly.

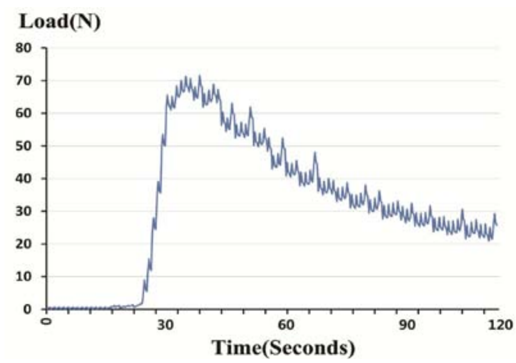

Figure 2: Typical change of compressive force according to time.

Gum typically is not stored in the refrigerator. However, pieces remaining after opening a new packet are frequently left in various places including in the car and near windows. When the temperature drops, the compressive strength of the gum left in these places is likely to increase as the gum hardens. In addition, dehydration during the long storage period can also change the hardness of gum [6].

The human tooth is a remarkably damage tolerant geometrical structure and is capable of sustaining the loads necessary to break down and process an enormous variety of foods through hundreds of thousands of load cycles over an adult human's lifetime [7,8]. At the same time, teeth are highly susceptible to fractures in areas of overloaded contact during normal chewing of food objects [9,10]. Among many studies on enamel fracture [11-15], an in vitro study in which a crosshead speed of 0.2 mm/min was used showed that damage (formation and growth of longitudinal cracks) may occur at remarkably low loads, as small as 100–200 N.8 This value is just slightly higher than the compressive strength of the gum pellet stored in the cold in the present study, especially in case of tooth antagonist. In fact, the temperature inside a car parked outside in the winter is frequently lower than -5^{o}C. In addition, the velocity of chewing would not be as slow as in our experimental setting, and a higher chewing velocity could contribute to an increase in impact energy. Fatigue fracture of tooth generally occurs from the existing crack and tooth with some kind of filling restoration are more vulnerable [16,17].

Chewing motion, velocity and cycle were reported to be influenced by the food bolus texture, hardness and size [18,19]. In other words, food characteristics could modify the output of the masticatory central pattern generator by altering proprioceptive feedback. The change in function may be due to regulation of the mechanical response of the jaw after an expected disturbance of the closing movement by food contact, resulting in a tuning of the muscle stiffness corresponding to the expected hardness of the food [20]. However, the initial velocity and motion probably depend on preexisting memory of the food texture. This means that unconsciously biting into gum stored in the cold based on a memory of normal hardness could lead to tooth fracture.

Recently, diverse beneficial health effects of chewing gum have been reported. In addition to minimizing dental caries, the effects of chewing gum on plaque accumulation, halitosis and xerostomia have also been studied [4, 21,22]. Treatment of gastroesophageal reflux disease [23] and reduction of postoperative ileus duration with chewing gum have also been reported [24]. Stress relief and enhancing cognitive function as a result of chewing gum were also reported in several studies [25]. These effects and other potential medical uses of chewing gum should be exploited, but with the appropriate precautions to prevent damage to tooth structures.

Conclusion

Gum has been reported to have many beneficial effects based on both its inherent characteristics as well as several additives. Given that chewing gum is commonly consumed for various purposes, caution should be exercised when chewing pellet type gum that has been stored in the cold in order to prevent unwanted tooth fractures.

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