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Characterization of Saqez as a natural chewing gum

Ash content, textural and thermal properties

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Abstract
In this study, oleo-gum resin obtained from wild pistachio trees (*Pistacia atlantica Desf. Subsp. kurdica*), known as Saqez, was used as a biodegradable, biocompatible, natural, and edible chewing gum. Saqez was characterized by ash content, texture profile analysis, and differential scanning calorimetry (DSC). Furthermore, Saqez was also compared to commercial chewing gum samples. The total ash content was found highest in chewing gums followed by Saqez. Moreover, all texture parameter values of Saqez were lower than conventional chewing gums. The analysis of DSC in Saqez confirmed that the glass transition temperature was comparable to commercial chewing gums. Saqez gum was seen to be an ideal replacement for a synthetic gum base in the manufacturing of a commercial chewing gum. The present study offers new information on Saqez gum, which will be precious and useful for explaining its unique textural properties and thermal behavior in the area of food science and technology.

Keywords Natural gum · TPA · DSC · Chewing gum · Ash content

Introduction

The natural gums are obtained as exudates from various tree species, which show special and varied physicochemical properties and have a wide variety of applications. Commercially significant tree gums include gum arabic, gum karaya, and gum tragacanth [1]. Gum arabic (*Acacia senegal*) is a branched, slightly acidic or neutral, complex polysaccharide obtained as a mixed magnesium, potassium, and calcium salt [2]. Karaya gum (*Sterculia urens*) has emulsifying, stabilizing, and thickening properties. It is one of the most used commercial food additives. It is a complex, partially acetylated polysaccharide obtained as a magnesium and calcium salt [3–5]. Gum tragacanth (*Astragalus gummifer*) is a complex, highly branched, naturally occurring as a slightly acidic calcium, heterogeneous polysaccharide, potassium, and magnesium salt [6].

Saqez is a natural polysaccharide obtained from wild pistachio trees that are mostly native to Iran [7, 8]. Also known as Baneh, *Pistacia atlantica Desf. Subsp. kurdica*, it is one of the most important oleo-gum resins of Zagros forests which are exuded from the trees throughout the growing time and hardens during the cold conditions and becomes smooth and melts when warmed. The maximum extraction of gum is in July and August, and the common tools for harvesting gums are axes for making deep wounds in the tree [9, 10]. These wounds have not any particular direction and are completely in the old-fashioned method. Between 10 and 50 wounds are generally cut, based on extract abundance, tree lushness, and height of the trunk. The other required material is a small clay bowl to put underneath the wound. After about 20 days of putting the bowls under the wounds, the collecting and production step starts and lastly the produced Saqez is sold in markets [11, 12]. Saqez is known because of its industrial and traditional applications in food and pharmaceutical formulations of the Zagros region since historical times [13].

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Saqez is a semi-dense, adhesive, liquid resin which is used in breath freshener, antiseptic, and comes in the shape of chewing gum for gastrointestinal problems, motion sickness therapy, and the main ingredient in the manufacturing of cosmetics, for example, toothpaste, products for the hair and skin and fragrances [10, 11, 14]. Its components contain α-pinene, terpenoids, and flavonoid [13, 15, 16]. The flavonoid of Saqez can prevent the growth and acid production of microorganisms involved in dental caries [16]. The natural Saqez extract features a bitter, spicy taste and contains considerable turpentine. Thus, it cannot be chewed. But, when it is boiled in water and its impurities are eliminated, its spicy taste reduces, and this product comes as typical Saqez available in the market [11]. The increasing demand in food industries for safe, low cost, simply handy and sustainable, environmental, biocompatible, natural, and biodegradable for gum has persuaded scientists and technologists to investigate for a new source of natural gums, as substitutes for synthetic ones, which are becoming more and more costly [17, 18]. To this conclusion, substitution of synthetic gum base with Saqez has great importance in many aspects.

TPA and DSC have a significant role to play in determining characteristics of chewing gum [19, 20]. Thus, instrumental measurements (TPA and DSC) may be done to acquire different information [21]. Generally, the most typical methods applied to distinguish various chewing gums from each other by specifying their texture are TPA and DSC. The former is beneficial to get data relating to the hardness, springiness, cohesiveness, chewiness, and adhesiveness of the products [22, 23], while the latter determines phase transitions of chewing gums [24, 25].

Despite a large number of articles published on chewing gums, no study has evaluated Saqez in the area of food science and technology. Furthermore, due to lack of adequate knowledge about TPA and DSC of Saqez, this study was carried out in order to evaluate chemical and textural properties as well as a phase transition of Saqez in comparison with four available chewing gums in markets.

Materials and methods

Materials

Traditionally produced Saqez was obtained from the local retailer, Kermanshah, Iran. It was stored in nylon bags and kept at the room temperature prior to the analysis. Four typical commercial gum products of different leading international brands were purchased from a local supermarket and labeled Gum-1 (Biodent; Masterfoodeh Company, Iran), Gum-2 (Five; Wrigley Company, USA), Gum-3 (Ice cubes; Hershey's Company, USA), and Gum-4 (Orion Banana; Orion Company, Korea), respectively.

Methods

Determination of ash content

The ash content was determined based on AOAC Official Method 923.03. [26]. About 2 g of sample was weighed into a porcelain crucible. Then, the sample was burnt in a furnace at 550 °C for 3 h until white ash is produced. The crucible was cooled in a desiccator before weighing. The total ash content was determined as follows (Eq. 1):

$$\text{Ash content}(\text{g}/100\ \text{g}) = \frac{\text{Mass of ash} \times 100}{\text{Mass of sample taken}} \quad (1)$$

TPA

TPA of chewing gums was determined using CT3 texture analyzer (Brookfield Engineering Inc., USA). To determine the hardness, resilience, adhesiveness, cohesiveness, springiness, and chewiness of the products, an aluminum probe P/35 (diameter 35 mm) was used for the study. The chewing gums with 10 × 10 mm and 3 mm in height were compressed twice to 20% of their original height with a speed of 2.0 mm s^{-1}. All samples were performed in this manner at room temperature [21, 27, 28]. These parameters were obtained by using the Texture-pro CT V1.2 Build 9 software.

DSC

A DSC analysis of chewing gums was performed using DSC (DSC 131, Setaram Instrumentation, France) with a chilling device. Samples were precisely weighed (16 mg) in TA aluminum pans and sealed, and the DSC curves were acquired at a rate of 10 °C min^{-1} from 0 to 200 °C. Nitrogen gas flow was kept at 20 mL min^{-1} [20, 28]. A blank aluminum pan was applied as a reference standard, and Data Processing Module version 1.54f software 2.04 (PerkinElmer) was used for the data analysis.

Statistical analysis

All analysis and experiments were performed in triplicate measurement. Analysis of variance (ANOVA) and Duncan's test ($p \leq 0.05$) were done on the analytical results through the statistical package SPSS 24.0 (IBM Corporation, New York City, New York, USA). The analyses were performed on all chewing gums types.

Results and discussion

The ash content

The total ash content of both Gum-3 (7.84 ± 0.15/100 g dry sample) and Gum-1 (7.81 ± 0.02/100 g) was found higher than Gum-2 (5.72 ± 0.37/100 g), Gum-4 (3.06 ± 0.22/100 g), and Saqez (0.29 ± 0.05/100 g). This indicates that the ash content of Saqez was lower compared to the commercial gum (Table 1). It has been reported that the ash contents of flaxseed, xanthan, guar, locust bean, karaya, and Arabic gums were 7.4%, 9.35%, 11.9%, 0.7%, 3.4%, and 1.2%, respectively [29–32]. Thus, low ash content in the Saqez shows that the total inorganic mineral is low.

TPA

Textural properties of the chewing gums are shown in Table 1 and Fig. 1. Hardness ranged from 6.48 to 16.46 N, with about 60% of the chewing gums showing values less than 10 N. The hardness value of all commercial chewing gums was much higher than the hardness value of Saqez, except for the case of Gum-1. Therefore, the initial chew of commercial chewing gums was harder than Saqez. According to Palabiyik et al. [33], low hardness value corresponds to chewing gum with the best chewing feeling. Santos et al. [20] studied the texture of chewing gum samples prepared from different microcapsules and found that hardness values of the chewing gum samples changed significantly. Thus, applying hardness value was also inadequate to get excellent chewing gums with ideal chewiness properties. Nevertheless, it is known that low resilience values are linked to good sensorial chewiness property [34]. As given in Table 1, resilience value of Saqez was significantly below the resilience values of commercial chewing gums. Additionally, adhesiveness value was also lower for Saqez, revealing a less sticky textural property among all products studied. The poorly adhesive product would not make the product stick to the teeth, which is favorable characteristics of chewing gum [21, 35]. The cohesiveness ranged from 0.45, 0.65, 0.80, 0.51, and 0.77 for Saqez, Gum-1, Gum-2, Gum-3, and Gum-4, respectively. The same outcome was seen for the cohesiveness values acquired, where in actuality the Saqez revealed lower cohesiveness. Springiness values revealed high difference which ranges from 1.19 to 1.64 mm. In comparison with other chewing gums, springiness value of Saqez was also lower. Chewiness is essentially the primary parameters of hardness, cohesiveness, and springiness (hardness × cohesiveness × springiness) [36]. Saqez showed lower chewiness than commercial chewing gums. Therefore, Saqez could promote the chewiness value since less energy is needed in the chewing process. These values given in Table 1 are similar to those explained by other authors for various chewing gums [20, 35, 37–39].

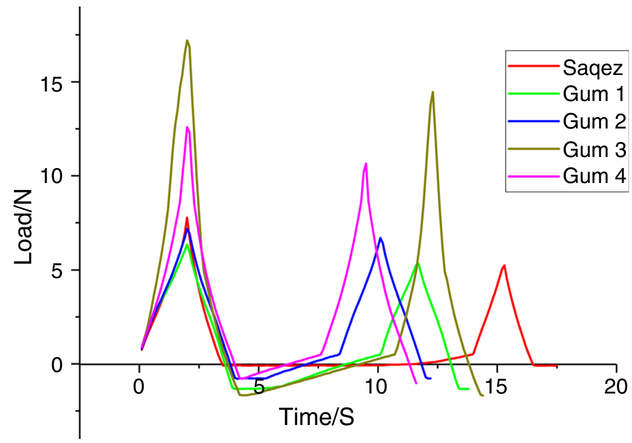

Fig. 1 Textural properties of Saqez and chewing gums

DSC

The DSC curves help to assess the glass transitions of chewing gums and reveal any change in controlling processes and products of samples [19]. The DSC curves of Saqez and all commercial chewing gums (Gum-1 to Gum-4) are displayed in Fig. 2. The DSC curve of Saqez

Table 1 Chemical composition and textural properties of Saqez and chewing gums

Gum type	Chemical composition	Textural properties					
	Ash/%	Hardness/N	Resilience	Adhesiveness/mJ	Cohesiveness	Springiness/mm	Chewiness/mJ
Saqez	0.29 ± 0.05[a]	7.86 ± 0.36[b]	0.49 ± 0.05[a]	0.13 ± 0.01[a]	0.45 ± 0.03[a]	1.19 ± 0.03[a]	4.35 ± 0.32[a]
Gum-1	7.81 ± 0.02[d]	6.48 ± 0.35[a]	0.60 ± 0.06[b]	0.94 ± 0.01[d]	0.65 ± 0.01[c]	1.50 ± 0.01[c]	6.50 ± 0.29[b]
Gum-2	5.72 ± 0.37[c]	7.15 ± 0.33[ab]	0.72 ± 0.05[c]	0.34 ± 0.01[c]	0.80 ± 0.01[d]	1.64 ± 0.02[d]	9.43 ± 0.35[c]
Gum-3	7.84 ± 0.15[d]	16.46 ± 0.37[d]	0.51 ± 0.02[a]	0.96 ± 0.01[d]	0.51 ± 0.01[b]	1.36 ± 0.03[b]	11.40 ± 0.46[d]
Gum-4	3.06 ± 0.22[b]	12.41 ± 0.36[c]	0.73 ± 0.05[c]	0.17 ± 0.01[b]	0.77 ± 0.01[d]	1.63 ± 0.04[d]	15.89 ± 0.61[e]

Different superscripts in the same column indicate that the means differ significantly ($p \leq 0.05$)

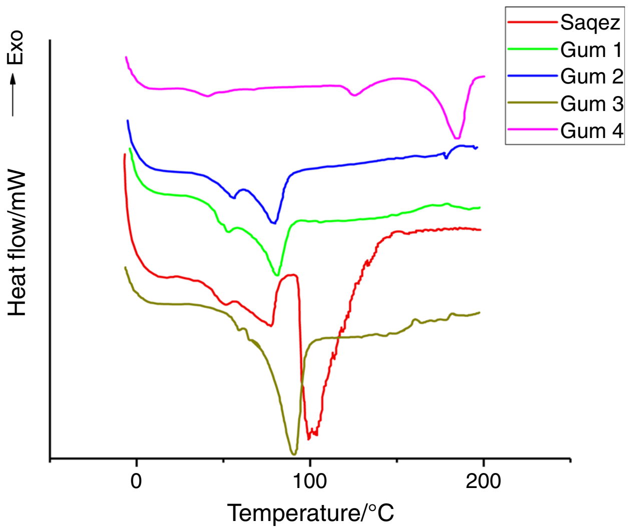

Fig. 2 Curves of Saqez and chewing gums

was similar to that of commercial chewing gums, whereas the shape of the endothermic peak of Saqez and Gum-4 was narrower than that of other samples. Saqez exhibited a single sharp melting endothermic peak at 93.57 °C with fusion enthalpy (ΔH) of 239.59 J g^{-1} because of amorphous nature of Saqez. Furthermore, this endothermic peak is due to the loss of water content in Saqez gum. Saqez showed a glass transition temperature (T_g) peak at 47.56 °C. Furthermore, Gum-1, Gum-2, and Gum-3 showed T_g near Saqez but showed melting endotherm peak at 69.59, 68.91, and 78.55 °C, respectively. Gum-4 displayed one T_g peak at 18 °C and exhibited melting endotherm peak at 41.85 °C, but it was different from other chewing gums. This might be due to the presence of more amount of moisture in the sample. The shift in T_g indicated that the synthetic gum base of commercial chewing gums had a direct effect on glass transition temperature, which can be an indicator of softness and elasticity of the commercial chewing gums [33].

Conclusions

Saqez can be introduced as a natural oleo-gum resin which generally includes polysaccharides. This gum can be used as an economic chewing gum in food industries. In this study, the physicochemical properties of Saqez were studied and compared with properties of commercial chewing gums. The Saqez gum has the lowest ash content, and TPA parameters (hardness, resilience, adhesiveness, cohesiveness, springiness, and chewiness) showed that it has good sensorial chewiness property. Furthermore, the DSC curve of Saqez was comparable to commercial gum and the endothermic peak of that was very high compared to that of synthetic gums. These good thermal properties make it useful for chewing gum processing. This information is very helpful for making decisions in regard to the substitution of synthetic gum base with Saqez. Because of the disadvantages of synthetic gums, the use of therapeutic plants is raising considering their low cost, availability, and biocompatibility. Hence, using these techniques can provide production of biocompatible, natural, and biodegradable products and guarantee the quality level of samples. In continuation, further studies ought to be done in order to recognize the antioxidant and antimicrobial activities of Saqez.

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