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Investigation of physicochemical and sensory properties of jelly produced from pectin extracted from ripe and unripe grape pomace under optimal conditions using traditional and ultrasonic methods

Kianoush Vakilian[1], Leila Nateghi[2*], Saba Belgheisi[3], Ladan Rashidi[3*], Mohammadreza Vafaee[4*]

[1] Department of Food Science and Technology, Mam.C., Islamic Azad University, Mamaghan, Iran

[2] Department of Food Science and Technology, VaP.C., Islamic Azad University, Varamin, Iran

[3] Department of Food, Halal, and Agricultural Products Research Group, Food Technology and Agricultural Products Research Center, Standard Research Institute (SRI), Karaj, Iran.

[4] Department of Biosystems Engineering, WT.C., Islamic Azad University, Tehran, Iran

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*Corresponding Author E-

leylanateghi@yahoo.com,
nateghi@iau.ac.ir;
ladan_rsh@yahoo.com;
Mohammadreza.vafaee@iau.ac.ir

ABSTRACT

With the increase in the production and processing of fruits and vegetables, many by-products containing valuable substances such as pectin are produced. Today, pectin is used as a gelling, thickening, texturing and emulsifying agent in many foods. Therefore, extracting pectin from grape processing by-products can be beneficial from both economic and environmental perspectives. The aim of the present study was to investigate the use of pectins extracted from grape pomace (ripe and unripe) by traditional and ultrasonic methods in jelly production and to compare its properties with commercial pectin (used in the control sample). Pectins extracted from unripe and ripe grape pomace were added to the jelly formulation at ratios of 0.75 and 1.5 percent, and the chemical, textural and sensory properties of the jelly were investigated. The results showed that increasing the pectin content from 0.75 to 1.5 resulted in a significant decrease in moisture content and syneresis and a significant increase in Brix content and hardness, adhesion, springiness, cohesiveness and chewiness. In terms of sensory properties, all jelly samples prepared from pectin extracted by traditional and ultrasonic methods and commercial pectin had high acceptance and the panelists did not observe any significant differences between them in the evaluation of taste, color, odor, texture and overall acceptance. Based on the results obtained, it was determined that the use of pectin obtained from grape pomace by ultrasonic waves with a low degree of esterification and a high level of galacturonic acid could be a suitable option for use in products with low sugar content, including jellies (with the presence of calcium).

1-Introduction

Pectin is a polysaccharide found naturally in most plants, although commercially it is mainly extracted from citrus peels, vegetable and apple pulp [1]. It is widely used as a gelling agent in the food industry, especially in the production of jellies and jams. Pectin is a polymer derived from acidic sugars, which is obtained from the gelatinous structures of fruits and vegetables. The highest pectin content is found in unripe fruits, while as the fruits ripen, the quantity and quality of pectin decreases [2]. The acids of the polymer may be methylated or free acids such as protopectin, gelatin acid, pectic acid and pectin. It is an important compound considering its desirable flavor, good processing properties and stability at low pH. In addition to acting as a gelling agent, pectin is used in various industries as a thickening and stabilizing substance [3]. Pectin is used in a wide range of foods, including fruit and bakery products, dairy products, fermented milk drinks, confectionery products as well as in the pharmaceutical industry. Since it is found in most fruits and vegetables, extensive studies have been conducted on the extraction of pectin from fruit waste [1]. Pectin plays an important role in the production of jams and jellies. In jams, pectin must form a gel immediately after filling for the fruit pieces to be evenly distributed, while in jellies, a delay can occur in gel formation to allow air bubbles to escape [4].

Pectin is commonly extracted by using a solution of mineral acids such as sulfuric, phosphoric, nitric, hydrochloric or citric acids at 60–100 °C and a pH value of 1.5–3 for 6 h. In addition to being time-consuming, this process has limitations regarding the quantity and quality of the extracted pectin [5]. Prolonged heating also causes thermal degradation of pectin, changing its physicochemical and functional properties. Therefore, traditional methods of pectin extraction may not provide the desired efficiency and quality [6].

Due to extensive use of pectin in the food industry and the importance of optimal use of agricultural waste, several studies have been conducted on the pectin extraction from alternative sources, e.g. extraction of pectin from pomegranate seeds [7], tomato peel pomace using different methods such as ultrasound (UAE), microwave, ohmic heating (OHAE), a combination of microwave and ultrasound, and ohmic heating and ultrasound [8], the extraction of pectin from Saveh pomegranate peel [3] and the extraction of pectin from fig peel using the microwave heating method [9]. Studies have also shown that ultrasound can destroy the cellular structure of plant tissues, thereby accelerating the extraction of intracellular contents [10]. Various studies revealed that the use of ultrasound could increase extraction efficiency and reduce the processing time [11-13]. Vakilian et al. (2023, 2024) compared two traditional and ultrasonic methods to extract pectin from unripe and ripe grape pomace. The results showed that the use of ultrasound significantly increased the extraction efficiency, reduced the degree of esterification and increased the galacturonic acid content. In the traditional method, the optimal conditions for unripe grape pomace included a pH value of 2.295 and a temperature of 80.28 °C for 120 min, and for ripe grape pomace included a pH value of 1.62 and a temperature of 60 °C for 120 min. In contrast, in the ultrasound method, the optimal conditions for unripe grape pomace included a pH value of 1.56, a temperature of 59.58 °C for 30 min, and for ripe grape pomace included a value of pH 3 and a temperature of 58.79 for 30 min. The use of ultrasound resulted in a decrease in extraction temperature and time and an increase in the extraction efficiency. Also, emulsions containing pectin extracted by the ultrasound showed higher stability than those containing pectin extracted by the traditional method [14, 15].

Therefore, in the present study, pectin was extracted from grape pomace appropriately, with the advantages being solving the problem of waste disposal, which leads to environmental pollution, and reducing costs. The effect of pectins extracted by the traditional and ultrasonic methods used in the production of jellies, on the physicochemical, textural and sensory properties was investigated.

2. Materials and Methods

2.1. Materials

Ripe and unripe grapes (Fakhri variety from a local market, Takestan, Iran), sugar (Golestan company, Iran), grape essential oil, permitted cherry red food color (Essence Iran Company, Iran) and commercial pectin extracted from unripe citrus and apple (Jahan Shimi Company, Iran) were prepared. Chemicals such as ethanol, calcium chloride, citric acid, phenolphthalein and 0.1 N sodium hydroxide were obtained from Merck Company (Germany).

2.2. Pectin extraction conditions and its physicochemical properties

The pectin used in this study was a product extracted from unripe and ripe grape pomace using the traditional and ultrasonic methods by Vakilian and his colleagues. Vakilian et al. (2023) reported that the pectin extracted under optimal conditions (pH = 2.95, 120 min, and 80.27 °C) from unripe grape pomace using the traditional method had an extraction efficiency of 18.48%, a galacturonic acid content of 53.76% and a degree of esterification of 43.49%, while under optimal conditions (pH = 3, 30 min, 58.84 °C) using the ultrasound method, the extraction efficiency was 28.43%, the galacturonic acid content was 63.94% and the degree of esterification was 31.02% [14]. Also, Vakilian et al. (2024) found that under optimal conditions from ripe grape pomace using the traditional method (pH = 2.99, 120 min, 66.42 °C), the extraction efficiency was 16.45%, the galacturonic acid content was 52.05% and the degree of esterification was 42.97%, while when using the ultrasound method (pH = 2.99, 30 min, 58.82 °C), the extraction efficiency was 24.25%, the galacturonic acid content was 61.39% and the degree of esterification was 27.78% [15].

2.3. Jelly preparation

To prepare jelly (Table 1), 0.75 and 1.5% of pectin extracted from grape pomace (ripe and unripe, Fakhri variety) under optimal conditions were mixed with 30% sugar (w), 0.014% of permitted food color and 0.75% of grape essential oil. Next, 100 cc of boiling water was added. After the sugar was completely dissolved, 30 mg of calcium chloride was added. The pH of the samples was adjusted to 2.5 using citric acid solution. Then, the samples were heated until the Brix value of the treatments reached 42. Finally, the prepared samples were kept at room temperature for 30 min and then refrigerated (4 °C) for 2-3 h for the jelly to become firm [16].

Table 1 – Formulation of jellies

Treatment	Pectin (%)	Pectin type (extraction method)
T1	0.75	Pectin extracted from ripe grape pomace by the traditional method
T2	0.75	Pectin extracted from unripe grape pomace by the traditional method
T3	0.75	Pectin extracted from ripe grape pomace by ultrasound
T4	0.75	Pectin extracted from unripe grape pomace by ultrasound
T5	1.5	Pectin extracted from ripe grape pomace by the traditional method
T6	1.5	Pectin extracted from unripe grape pomace by the traditional method
T7	1.5	Pectin extracted from ripe grape pomace by ultrasound
T8	1.5	Pectin extracted from unripe grape pomace by ultrasound
T9 (control 1)	0.75	Commercial pectin
T10 (control 2)	1.5	Commercial pectin

2.4. Tests

2.4.1. Chemical tests

Moisture content was measured using a vacuum oven by heating and cooling in a desiccator. Acidity was measured using the titration method in the presence of phenolphthalein and 0.1 N sodium hydroxide. Soluble solids content (Brix value) was measured using a benchtop refractometer at ambient temperature according to National Standard No. 2682 [17].

2.4.2. Syneresis measurement

Syneresis, which is one of the important physical factors in jelly production, was measured 2 hours after the jelly samples were formed using a 5000 g centrifuge at ambient temperature. The amount of liquid separated from the jelly was measured in graduated containers and the syneresis percentage was calculated using Equation 1 [18]

$$\text{Syneresis } (\%) = WL/WT \times 100 \quad (1)$$

Where WL is the total weight of separated liquid and WT is the total weight of jelly.

2.4.3. Texture profile analysis (TPA)

The texture profile and the textural properties were measured using a texture analyzer (model QTS25 CNS Farnell, UK). The samples were cut into 15 × 15 × 15 mm pieces and placed at ambient temperature. The loading was set to 5 kg (50 N). Then, each sample was compressed to 70% of its initial height over two reciprocating cycles by a cylindrical probe with a diameter of 35 mm at a speed of 60 mm/min and then decompressed [19].

2.4.4. Sensory evaluation

The sensory properties of the jelly samples prepared with pectin extracted from potato peel and commercial pectin were examined according to the method of Hoseinnejad et al. by 10 trained panelists using the 5-point hedonic method. Sensory properties including flavor, color, aroma, texture and total acceptance were evaluated. The scale included 1 = very bad, 2 = bad, 3 = average, 4 = good, 5 = very good [16].

2.4.5. Data analysis

Data were analyzed using one-way analysis of variance (ANOVA) and the means were compared by Duncan test at the 5% probability level using Minitab 16 software.

3. Results

3.1. Chemical properties of jelly

The chemical properties of jellies containing pectin extracted from unripe and ripe grape pomace using the traditional and ultrasonic methods, as well as jellies containing commercial pectin, are shown in Table 2. The moisture content of the samples ranged from 75.02% (T10) to 76.93% (T4). The acidity value ranged from 0.303% (T3 and T4) to 0.320 (T5). The Brix value of the jelly samples ranged from 17.47 (T4) to 18.44 (sample containing commercial pectin). Also, syneresis ranged from 28.15% (T8) to 47.46% (T2).

Table 2 - Moisture content, acidity, and Brix and syneresis valuesof jelly samples containing pectin extracted from unripe and ripe grape pomace using traditional and ultrasonic methods and commercial pectin-containing jellies

Treatments	Moisture (%w/w)	Acidity (%)	Brix (degrees)	Syneresis (%w/w)
T1	76.28 ± 0.17 ^{bc}	0.306 ± 0.002 ^{b}	17.77 ± 0.09 ^{ef}	46.04 ± 0.62 ^{a}
T2	76.12 ± 0.13 ^{bcd}	0.311 ± 0.003 ^{b}	17.86 ± 0.08 ^{def}	47.46 ± 0.45 ^{a}
T3	76.88 ± 0.24 a	0.303 ± 0.001 ^{c}	17.52 ± 0.14 ^{g}	42.92 ± 0.88 ^{b}
T4	76.93 ± 0.23 a	0.303 ± 0.001 ^{c}	17.47 ± 0.14 ^{g}	44.23 ± 0.82 ^{b}
T5	75.29 ± 0.04 ^{fg}	0.320 ± 0.004 ^{a}	18.25 ± 0.02 ^{ab}	32.47 ± 0.74 ^{c}
T6	75.75 ± 0.33 ^{de}	0.310 ± 0.002 ^{b}	18.05 ± 0.17 ^{bcd}	31.31 ± 0.99 ^{c}
T7	75.59 ± 0.46 ^{ef}	0.312 ± 0.003 b	18.12 ± 0.22 ^{bc}	29.18 ± 0.93 ^{d}
T8	75.90 ± 0.21 ^{cde}	0.309 ± 0.001 ^{b}	17.99 ± 0.10 ^{cde}	28.15 ± 1.08 ^{d}
T9 (control 1)	76.52 ± 0.20 ^{ab}	0.304 ± 0.003 ^{c}	17.69 ± 0.11 ^{fg}	43.78 ± 1.07 ^{b}
T10 (control 2)	75.02 ± 0.17 ^{g}	0.319 ± 0.005 ^{a}	18.44 ± 0.09 ^{a}	31.12 ± 0.72 ^{c}

Different lowercase letters in each column indicate significant differences ($p < 0.05$).

The results showed that jelly samples containing commercial pectin had lower moisture content than those containing extracted pectin. The difference could be attributed to the higher molecular weight and degree of esterification of commercial pectins, leading to greater interaction of water molecules with pectin through hydrogen bonds. In general, the incorporation of biopolymers into food formulations increases water holding capacity. Also, increasing the pectin concentration from 0.75% to 1.5% resulted in an insignificant decrease in the moisture content of the jellies, likely due to greater interaction of pectin with water and decreased free water content.

The acidity values showed no significant differences between the samples. The insignificant increase in the acidity of samples containing 1.5% pectin could be attributed to the release of galacturonic acid during storage. The Brix values of the jelly samples containing 1.5% pectin were higher than those containing 0.75% pectin. Higher pectin concentration can lead to increased jelly concentration and, as a result, increased dry matter content, which increases the Brix value.

Syneresis was shown to be higher in jellies containing 0.75% pectin than in jellies containing 1.5% pectin. Higher pectin concentration leads to stronger gel networks and lower water release. Especially jelly containing pectin extracted from unripe grapes by the ultrasonic method (T8) and 1.5% pectin showed the lowest syneresis, likely due to the higher galacturonic acid content and greater interaction of pectin with water.

The results revealed that there were differences in the physicochemical properties of jellies produced with different pectins, likely due to differences in the molecular structure of pectin, degree of esterification and extraction method [20]. Recent studies have also shown that increased concentration of polysaccharides such as pectin could improve the textural properties of jelly and reduce syneresis [4, 21]. The results of this study are in agreement with the findings of other studies, e.g. Zormand et al. [21] investigated the effect of replacing sucrose with maltitol and mannitol in jelly formulation and reported that it had no significant effect on the pH, acidity, Brix value and the moisture content, but there was a significant difference in syneresis, as jellies with reduced sucrose showed higher syneresis. Kashani et al. [4] also reported that there was no significant difference in the physicochemical properties (moisture content, acidity and Brix value) of the jelly samples prepared with potato peel pectin and those containing commercial citrus and apple pectin, while the syneresis showed a significant difference.

3.2. Textural properties of jelly

The textural properties of the jelly samples, including hardness, adhesiveness, springiness, cohesiveness and chewability, are presented in Table 3. Hardness, defined as the maximum force during initial compression which reflects the force needed to compress food between the molar teeth, ranged from 4.68 to 7.54 N. The lowest hardness value (4.68 N) was observed for T2 and the highest value (7.54 N) was found for T8. T2 contained 0.75% pectin extracted from an unripe source by the traditional method, while T8 contained 1.5% pectin extracted from an unripe source by the ultrasonic method. Increasing the pectin concentration led to an increase in the hardness of the jellies. Also, samples containing ultrasound-extracted pectin showed higher hardness than samples containing pectin extracted by the traditional method. In addition, the hardness of jelly samples containing pectin extracted from unripe sources was generally higher than that of samples containing pectin obtained from ripe sources. These results are consistent with the results obtained by other researchers [22, 23] in terms of the effect of pectin type and source on the hardness of jellies.

Adhesiveness, which refers to the work required to overcome the attractive forces between the food surface and the oral cavity [24], was significantly higher in T8 and T7. Previous studies have shown that increasing jelly hardness is usually associated with increasing adhesiveness [25], and this correlation was also observed in the present study. Increasing pectin concentration significantly increased the adhesiveness. Samples containing 1.5% pectin extracted by the ultrasonic method showed the highest adhesiveness, but the difference from the samples containing 1.5% pectin extracted by the traditional method was not significant ($p > 0.05$).

Springiness (elasticity), which indicates the ability of jelly samples to return to their original shape after being deformed by compression, ranged from 14.90 mm for T1 (containing pectin extracted from ripe grape pomace by the traditional method) to 24.96 mm for T10 (containing 1.5% commercial pectin). Increasing the pectin concentration from 0.75% to 1.5% increased the springiness of the jellies. Ultrasound-extracted pectin resulted in higher springiness compared to the pectin obtained by the traditional method. Also, samples containing pectin extracted from unripe sources showed higher springiness than those containing pectin obtained from ripe sources. These findings are in agreement with the results obtained by Kavitha et al. [26], who investigated jellies containing pomegranate juice, and also with the results obtained by Leelawat et al. [27], who studied vegetable jellies.

Increasing the pectin concentration led to an increase in cohesiveness. Samples containing ultrasound-extracted pectin showed higher cohesiveness than samples containing pectin extracted by the traditional method. The highest cohesiveness was observed for T7, T8 and T10. The samples containing 0.75% commercial pectin had similar cohesiveness to samples containing 0.75% pectin extracted from unripe sources by traditional and ultrasonic methods, while the use of 1.5% commercial pectin significantly increased cohesiveness ($p< 0.05$).

Cohesiveness, which indicates the structural integrity of the gel, inversely reflects the fragility during mechanical operation. The cohesiveness ranged from 0.153 N to 0.293 N, with the highest value being found for samples containing pectin extracted from unripe grape pomace by the ultrasonic method, likely due to their higher viscosity, which reduced breakage during compression [28]. Other researchers have stated that low cohesiveness facilitates chewing and swallowing, which was observed in jellies containing higher Spirulina concentrations [29].

Chewability was directly affected by increasing pectin concentration, showing significant ($p< 0.05$) differences. Samples containing pectin extracted by ultrasound showed higher chewability, with the highest value (50.51 mJ) being observed for T8. Samples containing pectin extracted from unripe sources also required higher energy for chewing. In jelly samples containing commercial pectin, increasing the pectin concentration to 1.5% resulted in a significant increase in chewability. Chewability, which describes the textural properties of solid foods [30], represents the energy required to chew food to make it suitable for swallowing [31]. The values obtained in this study (11.48 to 49.03 mJ) showed a trend similar to that of springiness and adhesiveness.

In general, the results of the measurement of textural properties after three hours (the time required for complete jelly setting) showed that the samples containing 1.5% pectin had better hardness, cohesiveness and chewability than the samples containing 0.75% pectin. T7 and T8, containing pectin extracted from unripe grape pomace using the ultrasonic method, showed higher hardness, cohesiveness and chewiness energy than the other samples, likely due to their higher galacturonic acid content and the increased molecular weight of pectin. Our results are in agreement with the results obtained by Kafili (2024) [29] on vegan kiwi jelly enriched with Spirulina extract who showed that the use of Spirulina had a significant effect on the hardness, springiness, cohesiveness, adhesiveness and chewability of the jelly.

Table 3 - Textural properties of jelly samples containing pectins extracted from unripe and ripe grape pomace using traditional and ultrasonic methods and compared to commercial pectin

Treatments	Hardness (N)	Adhesiveness (N.m)	Springiness (mm)	Cohesiveness (N)	Chewiness (mJ)
T1	4.80 ± 0.19 ^{ef}	0.0043 ± 0.0002 ^{d}	14.90 ± 0.34 ^{f}	0.160 ± 0.011 ^{d}	11.48 ± 1.18 ^{c}
T2	4.68 ± 0/19 ^{f}	0.0045 ± 0.0004 ^{cd}	17.16 ± 0.96 ^{e}	0.153 ± 0.007 ^{d}	12.35 ± 1.63 ^{c}
T3	5.24 ± 0.15 ^{d}	0.0047 ± 0.0004 ^{abcd}	18.16 ± 0.97 ^{de}	0.169 ± 0.001 ^{d}	16/13 ± 1.38 ^{c}
T4	5.11 ± 0.19 ^{de}	0.0046 ± 0.0005 ^{bcd}	18.76 ± 0.58 ^{d}	0.166 ± 0.018 ^{d}	15.95 ± 2.29 ^{c}
T5	6.86 ± 0.09 ^{c}	0.0051 ± 0.0002 ^{abc}	20.86 ± 0.35 ^{c}	0.250 ± 0.001 ^{c}	35.81 ± 0.89 ^{b}
T6	7.09 ± 0.26 ^{bc}	0.0053 ± 0.0004 ^{ab}	24.73 ± 0.32 ^{a}	0.269 ± 0.011 ^{b}	47.28 ± 4.06 ^{a}
T7	7.31 ± 0.15 ^{ab}	0.0054 ± 0.0003 ^{a}	22.2 ± 0.88 ^{b}	0.283 ± 0.005 ^{ab}	46.02 ± 3.28 ^{a}
T8	7.54 ± 0.17 ^{a}	0.0054 ± 0.0001 ^{a}	22.76 ± 0.40 ^{b}	0.293 ± 0.011 ^{a}	50.51 ± 3.73 ^{a}
T9 (control 1)	5.18 ± 0.28 ^{d}	0.0044 ± 0.0004 ^{cd}	18.83 ± 0.15 ^{d}	0.166 ± 0.012 ^{d}	16.30 ± 2.06 ^{c}
T10 (control 2)	7.13 ± 0.21 ^{bc}	0.0053 ± 0.0005 ^{ab}	24.96 ± 0.37 ^{a}	0.275 ± 0.016 ^{ab}	49.03 ± 3.75 ^{a}

Different lowercase letters in each column indicate significant differences ($p < 0.05$).

3.3. Sensory properties

The sensory properties of jelly samples containing pectin extracted from unripe and ripe grapes using traditional and ultrasonic methods, including flavor, color, odor, texture and total acceptance (total score) are shown in Table 4. The results showed no significant differences between the samples in color, odor and total acceptance ($p > 0.05$), suggesting that all samples were accepted by the panelists in terms of sensory properties. In other words, all samples had the desired sensory properties. However, T9 was given the highest texture score, followed by samples T3 and T4.

Table 4 - Scores for sensory properties of jelly samples containing pectin extracted from unripe and ripe grape pomace compared to commercial pectins

Treatments	Flavor	Color	Odor	Texture	Total Acceptance
T1	4.8 ± 0.42 ^{a}	5.0 ± 0.00 ^{a}	4.7 ± 0.48 ^{a}	4.5 ± 0.52 ^{bcd}	4.5 ± 0.52 a
T2	4.7 ± 0.48 ^{a}	4.9 ± 0.31 ^{a}	4.9 ± 0.31 ^{a}	4.6± 0.51 ^{bc}	4.4± 0.51 a
T3	4.8 ± 0.42 ^{a}	4.9 ± 0.31 ^{a}	5.0 ± 0.00 ^{a}	4.8 ± 0.42 ^{ab}	4.5 ± 0.52 a
T4	4.7 ± 0.48 ^{a}	5.0 ± 0.00 ^{a}	4.8 ± 0.42 ^{a}	4.8 ± 0.42 ^{ab}	4.7 ± 0.48 a
T5	4.7 ± 0.48 ^{a}	5.0 ± 0.00 ^{a}	5.0 ± 0.00 ^{a}	4.3 ± 0.48 ^{cde}	4.5 ± 0.52 a
T6	4.8 ± 0.42 ^{a}	4.8 ± 0.42 ^{a}	4.9 ± 0.31 ^{a}	4.3 ± 0.48 ^{cde}	4.4 ± 0.51 a
T7	4.8 ± 0.42 a	4.9 ± 0.31 ^{a}	4.8 ± 0.42 ^{a}	4.2 ± 0.42 ^{cde}	4.3 ± 0.48 a
T8	4.7 ± 0.48 ^{a}	5.0 ± 0.00 ^{a}	4.9 ± 0.31 ^{a}	4.0 ± 0.00 ^{e}	4.3 ± 0.48 a
T9 (control 1)	4.9 ± 0.31 ^{a}	4.8 ± 0.42 ^{a}	4.9 ± 0.31 ^{a}	5.0 ± 0.00 ^{a}	4.7 ± 0.48 a
T10 (control 2)	4.7 ± 0.48 ^{a}	4.9 ± 0.31 ^{a}	4.7 ± 0.48 ^{a}	4.1 ± 0.31 ^{de}	4.2 ± 0.42 a

Different lowercase letters in each column indicate significant differences ($p < 0.05$).

These findings are similar to previous results of the sensory evaluation of jellies. For example, Zormand et al. [21] reported that jellies containing sweeteners such as sucrose and maltitol or mannitol (up to 50% sucrose replacement) were accepted by the panelists and were practically approved for incorporation into the formulation of reduced-sugar jellies. This study showed that the use of sweetener substitutes in the formulation of jellies had no negative effect on sensory properties. Also, the positive effects of pectin extracted from ripe and unripe grape pomace using the traditional and ultrasonic methods are in agreement with the findings obtained by Kafili (2024) [29], who reported desirable sensory properties, including flavor, odor, color, texture and total acceptance, of the vegan kiwi jelly samples enriched with Spirulina extract. Regarding the use of pectins extracted from other natural sources, Kashani et al. [4] also stated that there was no significant difference in the sensory properties of jellies prepared with potato peel pectin and commercial jellies containing citrus and apple pectin, suggesting the feasibility of using non-commercial pectins (such as potato peel pectin) in the production of jellies with sensory properties similar to commercial jellies, especially under optimal conditions. The results demonstrated that different pectin sources and methods of extraction had no significant effect on the sensory properties of jellies and that change in the source and method could optimize jelly formulations without negative changes in sensory properties. Also, the results indicated the great potential of using modern pectin extraction methods (such as ultrasound) for the production of jellies with acceptable sensory properties in the food industry.

4. Conclusion

The results of this study showed that the use of 1.5% pectin compared to 0.75% slightly reduced the moisture content of the jellies, likely due to the increase in pectin concentration and the decrease in water exchange in the jelly matrix. Also, 1.5% pectin significantly reduced syneresis, especially in the jelly samples prepared with pectin extracted from unripe sources using the ultrasound method (T8 showed the lowest syneresis), suggesting improved structure of the jelly and decreased water loss. Increasing the pectin concentration from 0.75% to 1.5% also led to an increase in the Brix value of the jellies, indicating a higher concentration of solid matter in the jelly solution. Samples containing 1.5% pectin showed higher hardness, adhesiveness, springiness, cohesiveness and chewiness, with the highest values observed for T7 and T8. The results indicated that increasing the concentration of pectin, especially pectin extracted from unripe and ripe sources by modern methods such as ultrasonication could result in jellies with the desirable sensory properties without any negative effect on their quality. All samples prepared with pectin showed high acceptance and the panelists did not observe any significant differences in flavor, color, odor, texture and total acceptance, indicating that the use of pectins extracted from unripe and ripe sources, especially pectins extracted by modern methods such as ultrasound, could effectively maintain the sensory properties of jellies without any negative effects. Therefore, pectin extracted from grape pomace using the ultrasound method with a low degree of esterification and high galacturonic acid content, is suitable for the production of low-sugar jellies and other similar products such as jams, marmalades and pastilles. They can be specifically manufactured as dietetic products, replacing the traditional high-sugar ones. These findings also highlight the potential of pectins extracted from unconventional sources (such as grape pomace) as a sustainable and suitable raw material in the low-sugar food industry and can pave the way for the development of food products with optimal properties.

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بررسی خواص فیزیکوشیمیایی و حسی ژله تولید شده از پکتین استخراج شده از تفاله انگور رسیده و نارس در شرایط بهینه به روش سنتی و فراصوت

کیانوش وکیلیان[1]، لیلا ناطقی[2]*، سبا بلقیسی[3]، لادن رشیدی[3]*، محمدرضا وفایی[4]*

١-گروه علوم و صنایع غذایی، واحد ممقان، دانشگاه آزاد اسلامی،ممقان، ایران

٢-گروه علوم و صنایع غذایی، واحد ورامین-پیشوا، دانشگاه آزاد اسلامی، ورامین، ایران

٣-گروه پژوهشی مواد غذایی حلال و فرآورده های کشاورزی، پژوهشکده صنایع غذایی و فرآورده های کشاورزی، پژوهشگاه استاندارد، کرج، ایران.

٤-گروه بیوسیستم، واحد تهران غرب، دانشگاه آزاد اسلامی، تهران ، ایران

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* مسئول مکاتبات:

leylanateghi@yahoo.com,
nateghi@iau.ac.ir;
ladan_rsh@yahoo.com;
Mohammadreza.vafaee@iau.ac.ir

چکیده

همراه با افزایش تولید و فرآوری میوه و سبزیجات، فرآورده‌های جانبی زیادی که دارای مواد باارزشی مانند پکتین می‌باشند، بوجود می‌آید. امروزه پکتین به‌عنوان یک ماده ژل کننده، قوام‌دهنده، بافت‌دهنده و امولسیون‌کننده در بسیاری از مواد غذائی کاربرد دارد. از این رو استخراج پکتین از محصولات جانبی فرآوری انگور، می‌تواند هم از جنبه اقتصادی و هم زیست‌محیطی سودمند باشد. هدف از تحقیق حاضر بررسی استفاده از پکتین‌های استخراج شده از تفاله انگور (رسیده و نارس) به روش سنتی و فراصوت در تولید ژله و مقایسه خواص آن با پکتین تجاری (مورد استفاده در نمونه شاهد) بود. پکتین‌های استخراج شده از تفاله انگور نارس و رسیده با نسبتهای ٠/٧٥ و ١/٥ درصد به فرمولاسیون ژله اضافه شد و ویژگیهای شیمیایی، بافتی و حسی ژله بررسی قرار گرفت. نتایج نشان داد که افزایش میزان پکتین از ٠/٧٥ به ١/٥ باعث کاهش معنی‌دار در میزان رطوبت و سینرسیس و افزایش معنی‌دار در میزان بریکس و مقادیر سختی، چسبندگی، فنریت، به هم پیوستگی و قابلیت جویدن گردید. از نظر ویژگی‌های حسی، همه نمونه‌های ژله تهیه‌شده از پکتین استخراج شده به روش سنتی و فراصوت و پکتین تجاری، دارای پذیرش بالایی بودند و پانلیست‌ها هیچ اختلاف معنی‌داری بین آنها در ارزیابی طعم، رنگ، بو، بافت و پذیرش کلی مشاهده نکردند. براساس نتایج بدست امده، مشخص گردید که استفاده از پکتین بدست امده از تفاله انگور به روش امواج فراصوت با درجه استریفیکاسیون پایین و میزان گالاکتورونیک اسید بالا، گزینه مناسبی می‌تواند برای استفاده در محصولات با میزان شکر کم از جمله ژله‌ها (با حضور کلسیم) باشد.