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# Study of physicochemical and sensory properties of yoghurt fortified with pectin extracted from the apple peels and pomace

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## Abstract

This study aimed to extract pectin from apple peels and pomace of all kinds (red, yellow and green) by citric acid, and study the chemical composition of apple peel and pomace powder which included the percentages of moisture, protein, fat, fiber, ash and carbohydrates. It also showed the chemical composition of the extracted pectin, which included moisture, ash, equivalent weight, methoxyl content, anhydronic acid , and the degree of esterification. Then, pectin was added at two concentrations (0.1 and 0.3)% to the yoghurt made from fat-free sorting milk. physicochemical properties and were conducted for yoghurt treatments A1,A2,B1,B2,C1,C2,D1,D2 and control treatment which include moisture, protein, fat, carbohydrate and ash, as well as the sensory evaluation was conducted for 14 days after manufacture of refrigerated storage . The results showed a high percentage of protein, carbohydrates, fat and ash, as well as a decrease in the percentage of moisture, and this is due to the role of added pectin, and the results of the sensory evaluation test for 14 days gave that the best concentration of the addition is 0.3% to improve the qualitative properties and consumer acceptance. The study also showed the identification of effective compounds in extracted pectin by FTIR technology.

**Key words:** pectin extraction, chemical composition of pectin, fortified yoghurt,. physicochemical and Sensory properties, Diagnostic by FTIR Technology

## 1 .Introduction

The process of processing fruits and vegetables results in the production of large quantities of waste, which constitutes about (25% - 30 %) of whole fruit . This waste must be converted into beneficial products [1] thus, there is a need to consider the origins of recycling and production of beneficial ingredients [2] .The waste consists mainly of seeds,

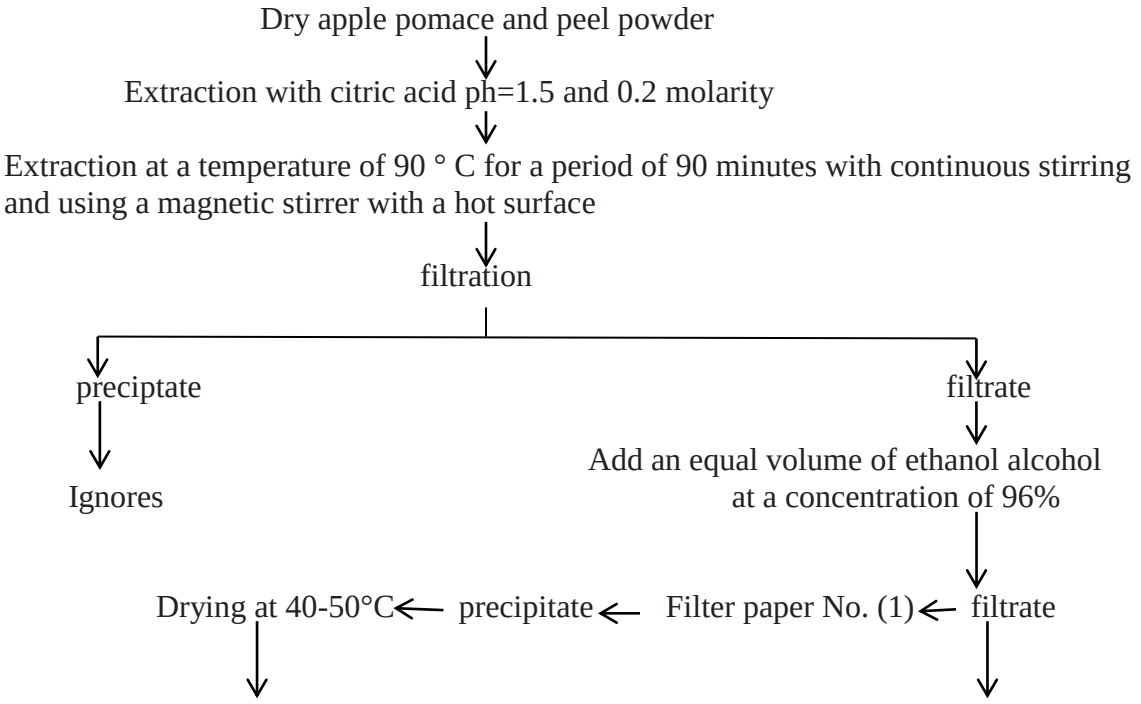
husks and pomace which contains more sources of bioactive compounds like fiber and others, which are beneficial to human health [3]. The feasible theory to increase the daily intake of dietary fiber is the production dairy products fortified using dietary fiber, such as dairy products that are consumed daily in most people's meals, to improve the nutritional values, the physical texture of the products, and meet the requirements of consumers. Dietary fiber can also be re-used as a component rich in dietary fiber in food manufacturing, so fortification of fortified dietary fiber such as those in fruit and vegetable products processing waste, considered a good way to increase the consumption of dietary fiber [4]. Dairy products are an important component of the human diet, and yoghurt is currently one of the common dairy products. Consumers prefer yoghurt for its flavour, as well as its nutritional value and health-promoting effects. In addition, it is characterized by the properties of functional food that are in high demand. [6] , [5] , as it can be added by-products rich in fiber and used directly or indirectly to manufacture foods that are beneficial to health, such as yoghurt [4].

## 2.Materials and Methods

2.1. The material used for extracting pectin is the peel and pomace of apples of the type of apple (red, yellow and green). The samples were brought from the markets of Babylon Governorate and were washed and cleaned, then the samples were peeled and the peels and pomace were extracted and dried at a temperature of 40-50 ° C, then they were ground by a home grinder and placed In plastic containers until use.

2.2. The used cow's milk was prepared from one of the farms in the province of Babylon, and the milk quality tests were conducted on it, and it was prepared for the manufacture of yoghurt.

2.3 . Scheme showing the method of extracting pectin with citric acid.



Crushed and stored in plastic containers Ignores

2.4.

The cow's milk was prepared and separated by a sorting device in the dairy technology laboratory and prepared for the manufacturing process. The fat-free milk was heated to a temperature of 90°C for 10 minutes and once it was cooled to 50°C, the pectin was mixed well with continuous stirring at concentrations of 0.1 and 0.3% and added to milk is then inoculated of Streptococcus thermophilus (YC-X16) and Lactobacillus bulgaricus (CHN-11) from S2 1L/. At a temperature of 45°C, it is added in plastic containers of 100ml capacity in three replications, then incubated at 42°C for 5-6 hours, then the added milk with pectin is cooled at 4-5°C for 14 days.

**3.Chemical composition tests of apple peel and pomace powder:**

3.1. The estimation of moisture, ash percentage, fat percentage (in saxolites), protein by Keldahl method and fiber : according to the standard method mentioned in [7].

**3.2.Estimation of the percentage of carbohydrates:** the percentage of carbohydrates in the powder of apple peel and pomace was estimated as the difference between the total components, according to the method mentioned by [8] .

**4.Chemical analysis of pectin**

**4.1.Moisture estimation**

Moisture was estimated according to [9] by placing 0.1 g of pectin extracted from apple peels and pomace in a thermal oven at 130 °C until a constant weight was obtained.

**4.2.Ash estimation**

The ash was estimated as indicated [9] by placing 0.1 g of pectin extracted from apple peels and pomace in an incineration oven at a temperature of 550 °C until a grayish-white ash was obtained.

**4.3.Equivalent weight estimation**

Equivalent weight was estimated according to[10] method by weighing 0.5 g of pectin extracted from apple peel and pomace and wetting it with 5 ml ethanol 99% in a 250 ml erlenmeyer flask. Then 1 g of sodium chloride was added. The mixture was dissolved in 100 ml of distilled water, then 5-6 drops of phenol red reagent were added, and the contents of the flask were wiped with 0.1 N NaOH until pink color (PH7.5) appeared. The final volume was recorded from the base, then the equivalent weight was calculated from the equation:

Equivalent Weight(gm.Eq.) = (1000 x (g) Weight sample) / (Sodium Hydroxide Standard x Sodium Hydroxide Volume)

**4.4.Determination of methoxyl content**

Methoxyl is estimated according to the method by [10] , using the neutral solution obtained during the process of estimating the equivalent weight, to which 25 ml of 0.25 N sodium hydroxide was added directly, the contents of the flask were mixed well and left for 30 minutes at laboratory temperature before adding 25 ml of 0.1 N hydrochloric acid, and then smeared with sodium hydroxide 0.1 N, with stirring until the pH reached 7.5, recorded the final volume, and the methoxyl degree was calculated from the following equation:

$$100 \times \frac{31 \times N\ NaOH \times Volum\ of\ NaOH}{Wight\ of\ sample} = \%\text{degree of methoxcyle}$$

Molecular weight of methoxyl group OCH3 = 31

**4.5.Pectin content of anhydronic acid**

The percentage of anhydronic acid (AUA) was calculated in the pectin samples according to the method mentioned by [11] according to the following equation:

$$\frac{100 \times 176}{Z} = \%AUA$$

where represents the value of Z = $\frac{\text{( mg) Wight of sample}}{\text{methoxyl pectin content + Equivalent weight}}$

**4.6.**

**Estimation of the degree of esterification**

Degree of esterification was determined according to the method of [12] by wetting 100 mg of pectin extracted from dried apple peels and pomace with 2 ml of 99% ethanol, and dissolved in 20 ml of distilled water at a temperature of 40 ° C with stirring. Then 5 drops of phenolphthalein reagent were added and crushed. The solution with 0.1 N NaOH was recorded and the initial volume was recorded .Then 10 ml of 0.1 NaOH was added under stirring and the sample was left for 20 minutes, then 10 ml of 0.1 ml hydrochloric acid was added, stirring vigorously until the disappearance of the pink color .Then 5 drops were added of phenolphthalein again and flush the solution with 0.1 N NaOH until a pale pink color appears. The final volume was recorded and the degree of esterification was calculated by applying the equation:

$$\mathbf{100} \times \frac{\boldsymbol{Final\ volum\ of\ NaOH}}{\boldsymbol{final\ volum + Initial\ volum}} = \boldsymbol{DE}\%$$

**5.**

**Chemical properties of yoghurt with added pectin**

5.1.**Determination of moisture, ash and protein** : The percentage of moisture, ash and protein in yogurt were estimated according to [7].

**5.2.Fat estimation:** The percentage of fat in yogurt samples was estimated using method according to the British Standard Institution[13] .

**5.3.Estimation of carbohydrates:** their percentage was estimated mathematically by the difference method according to what was mentioned by [14]

carbohydrates = 100- % (protein + fat + moisture + ash)

**6.Fourier transform infrared spectrometry (FTIR)**

Measurement of the PerkinElmer Fourier Transform Infrared Spectrophotometer at a frequency between 400 and 4000 cm-1 with a precision of 4 cm-1 per second using (KBr) for pectin studied using potassium bromide pellet method.

**7.Sensory evaluation for Yugurt**

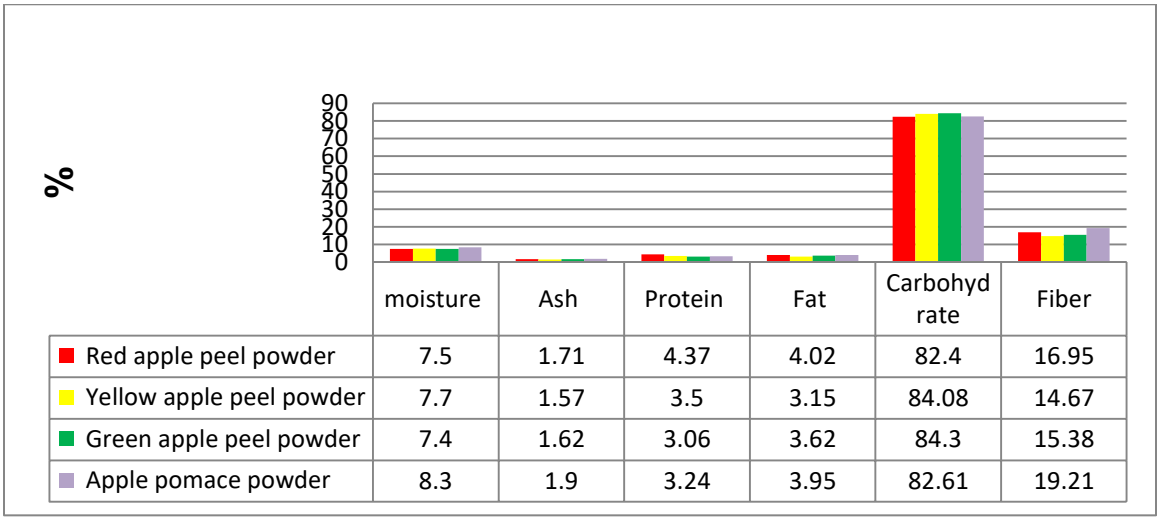
Sensory evalution for yogurt were conducted in the Department of Dairy Science and Technology - College of Food Sciences -Al-Qasim Green University by a number of specialized professors according to the Nelson sensory evaluation form, which included the characteristics of flavor, texture, color, appearance and whey clarity established by [15].

**8.statistical analysis**

Statistical Analysis System -SAS (2018), the statistical program used the data to study the effect of different treatments on the studied properties according to a complete random design (CRD), and the significant differences between the means are compared according to the least significant difference(LSD) .

## 9.Results and Discussion

### 9.1.The Chemical Composition of apple Peel and Pomace




| | moisture | Ash | Protein | Fat | Carbohydrate | Fiber |
|---|---|---|---|---|---|---|
| Red apple peel powder | 7.5 | 1.71 | 4.37 | 4.02 | 82.4 | 16.95 |
| Yellow apple peel powder | 7.7 | 1.57 | 3.5 | 3.15 | 84.08 | 14.67 |
| Green apple peel powder | 7.4 | 1.62 | 3.06 | 3.62 | 84.3 | 15.38 |
| Apple pomace powder | 8.3 | 1.9 | 3.24 | 3.95 | 82.61 | 19.21 |

Figure (1) Chemical composition of apple peel and pomace

Figure (1) shows the results of the chemical composition of the apple peel and pomace of the local variety under study. It also shows that the moisture content of the apple peel and pomace was between (7.4-8.3)%, as it was in the apple peels of (red, yellow, green, and pomace). They are (7.5,7.7,7.4 and 8.3) respectively, this is consistent with what is found by [16], where they indicated that the moisture content in apple pomace was 7.1%, while [17] , they mentioned that the moisture content in apple peels and pomace was 10.5% , Where these results were slightly higher than our results .

Also figure (1) shows the percentage of ash in apple peels and pomace, where it reached between (1.57-1.9)%, as it was in the apple peels of (red, yellow, green, pomace) they are (1.71, 1.57, 1.62, 1.9%) respectively. This result is consistent with what is reached by [18] when they studied apple peels, which amounted to 1.65%, while [17], they concluded that ash in apple pomace was 2.5%, whereas [19] they indicated that ash in the pomegranate peels amounted to 3.43%. Our results were less than what was found by [20], which amounted to 5.49% when they studied the percentage of ash in the peels of the pomegranate.

Figure (1) also shows the percentage of fat in apple peels and pomace, as it ranged between (3.15-4.02)%, as it was in the apple peels of (red, yellow, green, pomace) they are (4.02, 3.15, 3.62, 3.95)% respectively. And these results were similar to what was mentioned by [21], who indicated that the fat was 4.2%, when they studied the percentage of fat in apple pomace and with [22] where they mentioned that the percentage of fat in apple pomace is 4.2%. Our results were consistent with what is reached by [23] where they indicated that the percentage of fat in apple pomace was 3.8%.

As for the percentage of protein, as shown in Figure (1), it reached between (3.06-4.37%) in apple peels and pomace. Where the percentages of protein were (4.37, 3.5, 3.06, 3.24%) for (red, yellow, green, pomace) respectively, these results fall within what was mentioned by [24] where they indicated that protein in apple peele and pomace was 3.2. Also, our results were slightly less than what was found by [25] where they mentioned that protein in apple pomace was 4.8 %.

Figure (1 ) also shows the percentage of carbohydrates in apple peels and pomace, which ranged between (82.4-84.3)%, as it was in the apple peels of (red, yellow, green, pomace) they are (82.54, 83.94, 84.3, 82.61)% respectively. this is consistent with what is found by [24] where they indicated that carbohydrates apple peels and pomace was 81.87% , and slightly less than what was found by [26] where he indicated that carbohydrates in apple pomace is 93.0% and [27] where he indicated that carbohydrates in apple peels is 87.43%.

Figure (1) shows the percentage of fiber in apple peels and pomace, as it was in the apple peels of (red, yellow, green, pomace) they are (16.95, 14.67, 15.38, 19.21) respectively, these results are close to what was found by [17 ] where they mentioned that the percentage of fiber in apple pomace was 14.5%, and less than what was found by [24], where they mentioned that the percentage of fiber in apple peels and pomace was 43.89% and [22], where they found that the percentage of fiber in apple pomace is 26.5% While [27] he was found that the percentage of fiber in the commercial apple peel powder was 21.53%, and it also estimated the percentage of fiber in the test apple peel, which was 41.93%. The reason for the difference in the proportions of the chemical components of the apple peels and pomace under study with the findings of previous studies is due to the difference in the studied varieties, as well as the different conditions of their cultivation, the degree of perfusion of the varieties, soil service processes, storage conditions and sampling methods, and this was confirmed by [28]. The reason for the difference in the proportions of carbohydrates is the difference in the

proportions of other components, as the carbohydrates were estimated by the difference between the components, which means that the increase or decrease in the percentage of any of the estimated components affects the calculated carbohydrate percentage, and this is what was indicated by [29].

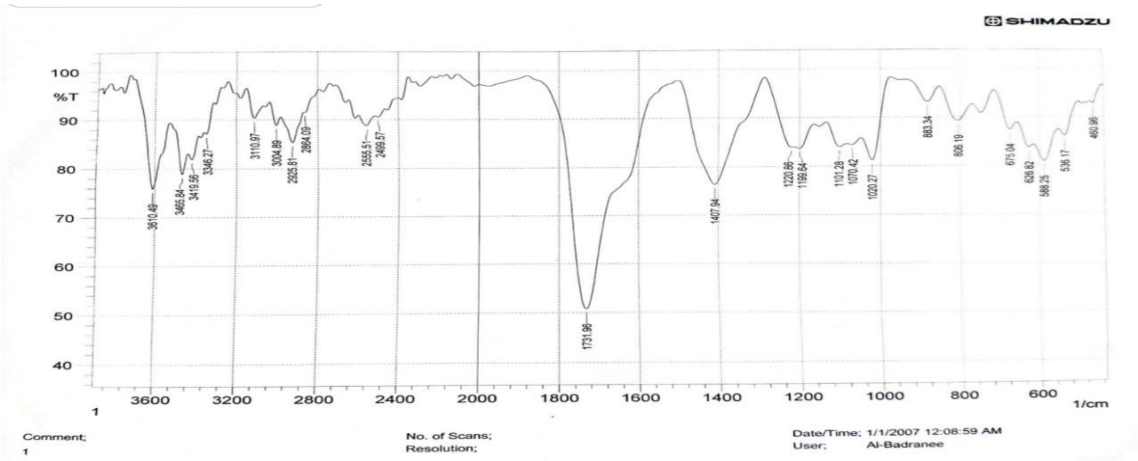
**9.2.Infrared spectroscopy FTIR**

The functional groups found in apple peel and pomace extract are included in the range (400-4000 cm-1) as shown in (Table. 1 ), the present group is characterized as strong and broad (OH-group started with hydroxyl group, peak 3616). The appearance of the hydroxyl group indicates that water is one of the components of the extract, and there is an extended bond of the hydroxyl group extended and connected to the next functional group at the double peaks of 2927 cm-1 and 2574 cm-1 in addition to molecules representing the amide organic complex of collagen, mannose and pectin as well as the active constituents such as the phenolic group in apple peels and these findings agree with findings by [31], [30] . In the regions of the peaks 1733 cm-1 to 1728 cm-1 refers to the functional groups C = O, the carbonyl group that may have belonged to the carboxyl-carbonyl group , which referred to amide compounds and acids [31] , As indicated by the functional groups (c=o) to the presence of polar phenolic compounds, which were mentioned in the study [32], the formation of the carboxyl group occurs due to the oxidation of a few atoms [33]. The spectrum, which is absorbed at the peaks from 1402 cm-1 to 1411 cm. Carbon 1-1 assigned to an aromatic benzene ring, which is linked in an acetyl group 1620 cm- refer to C=C functional group indicating the presence of medicinal aromatic components, while peaks 775 cm -1 represents the group C-H , at peaks 1641 cm −1 to 1735 cm −1 there is an ionic ketone shift, due to moisture. Apple peel and pomace extract contains a number of the most active groups, namely amine groups, hydroxyl groups, carboxyl groups, and carbonyl groups, in addition to aldehydes and ketones, and may also contain an aromatic and medicinal benzene ring.

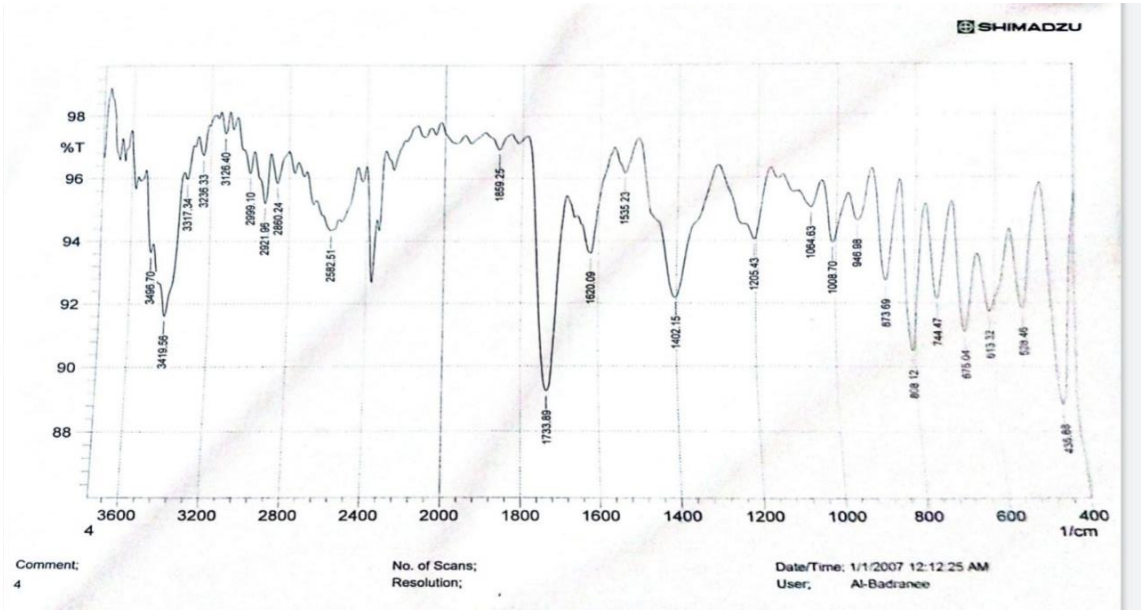
Table ( 1) Active groups in pectin by FTIR technology

| OH ($cm^{-1}$) | CHN ($cm^{-1}$) | Amide ($cm^{-1}$) | C-H ($cm^{-1}$) | - OH ($cm^{-1}$) | **Functional group** |
|---|---|---|---|---|---|
| 588 | 1407 | 1731 | 2925<br>2864 | 3610<br>3465 | Red apple peel pectin |
| 601 | 1407 | 1735<br>1641 | 2921<br>2858 | 3425<br>3371 | Green apple peel pectin |
| 671 | 1411 | 1728<br>1625 | 2927<br>2574 | 3616<br>3562 | Apple pomace pectin |

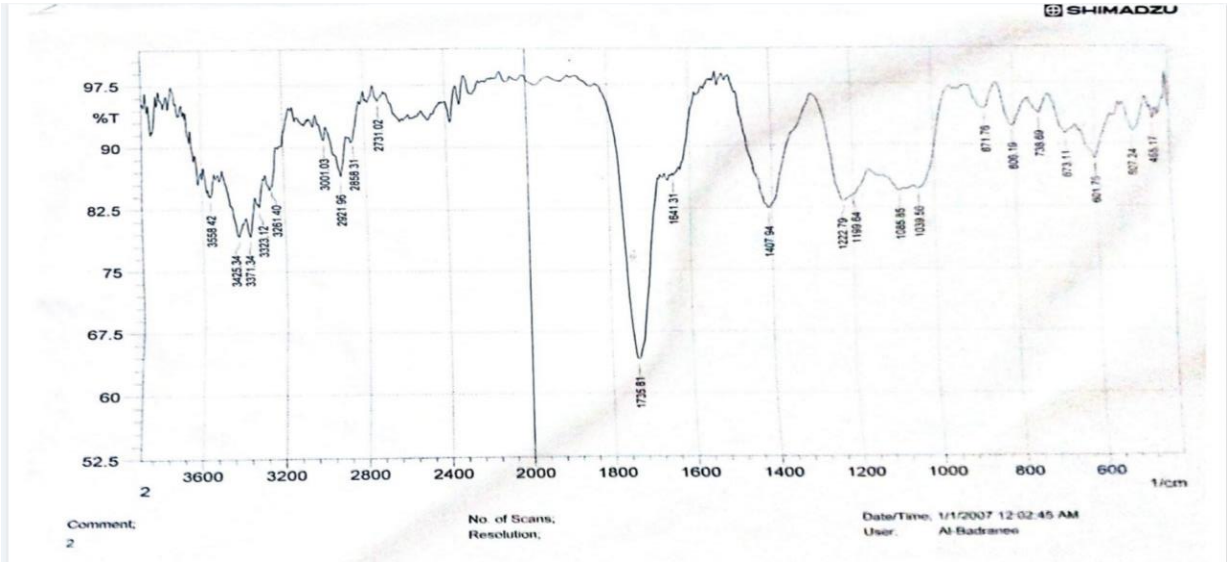
| | | | | | |
|---|---|---|---|---|---|
| 435 | 1402 | 1733<br>1620 | 2921<br>2582 | 3496<br>3419 | Pectin of yellow apple peels |



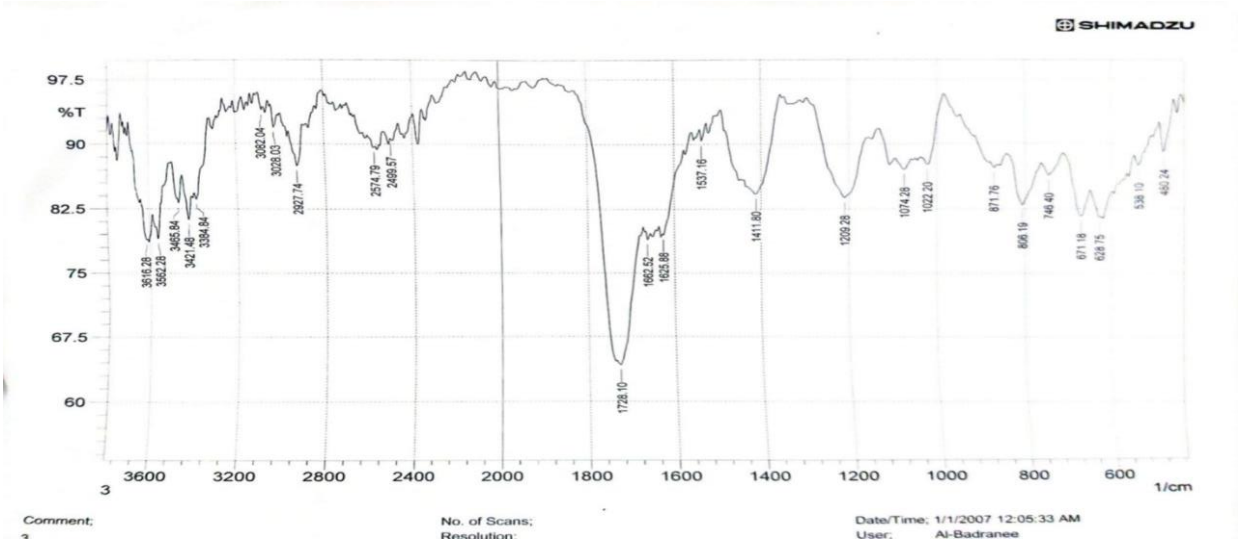

(A) Pectin from red apple peels




(B) Pectin of yellow apple peels




(C)Pectin from green apple peels




(D) Pectin from apple pomace

**9.3.**

**The chemical composition of pectin**

**9.3.1.Moisture determination**

Figure ( 2) shows the moisture content of pectin powder, which ranged between (9.1-10.2)%, the pectin content of apple peel and pomace were (9.1,10.2,9.4, 9.3)% for (red, yellow, green, pomace) respectively, Our results were slightly higher than the results reached by [34 ], where they stated that the moisture content in apple pomace pectin is 8.80%, Also, the results of this study are within the limits of quality of pectin (IPPA), which determined the maximum acceptable moisture content 12%, results of this study is slightly consistent with what is found by [35] where they showed that the moisture content of

pectin prepared from apple peels (red, yellow and green) was between 10.3-11.35%, where the lowest percentage in red apples was 10.3% and the highest percentage in yellow apples amounted to 11.35%

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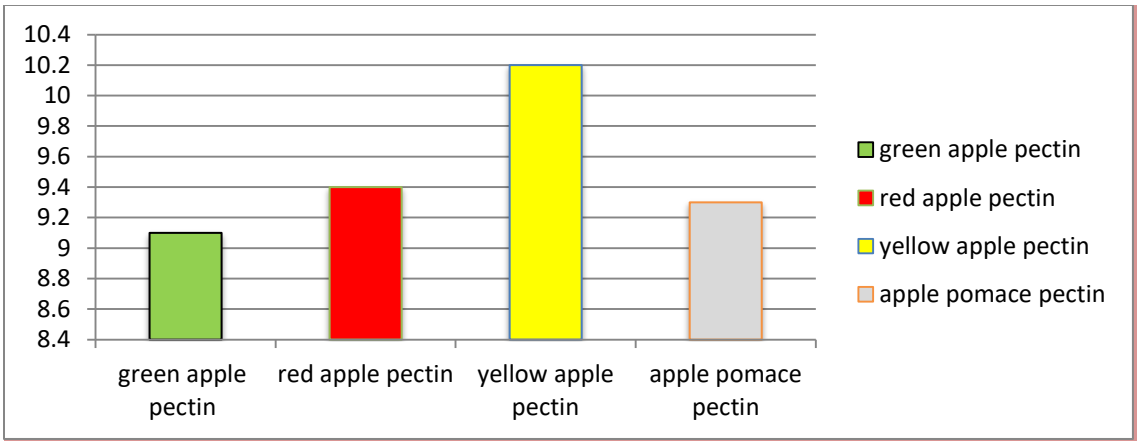


Figure (2) Moisture content of pectin

**9.3.2.**

**Ash Determination**

Figure ( 3) shows the percentage of ash in pectin powder for apple peels and pomace, which ranged between (1.7-2.3%), the ash content in apple peels and pomace (red, yellow, green, pomace), were (1.9, 2.0, 1.7, 2.3%) respectively, these results are close to what was reached by [35] Where they found that the percentage of ash in apple peels were between (1.2-2.2)%, Also, these results are consistent with what was reached by [2 ] , where they mentioned that the ash in apple pomace pectin was 1.69 %, as well as this results slightly consistent with what is found by [18] and, where they mentioned that the percentage of ash in apple pectin was 1.4 %. The reasons for the difference of the ash content in pectin extracted from fruit samples is due to the difference in the type of sample and extraction conditions, and since the raw material included in this study is apple peels (green, yellow, red and pomace), it is possible that the difference in ash percentages is due to the difference in the stages of maturity, but all ash values were within the permissible limit, as indicated by [36]

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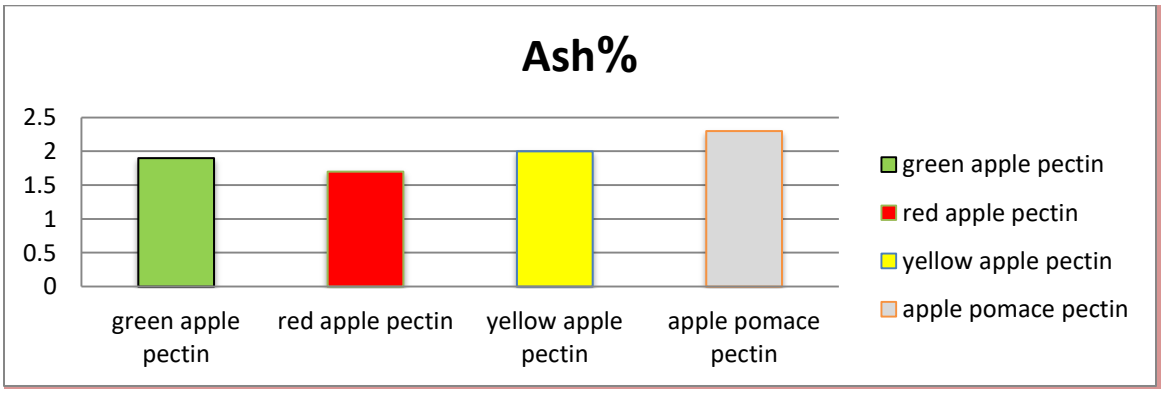



Figure (3 ) content of ash in pectin

**9.3.3.**

**Equivalent weight**

Figure (4) shows that the equivalent weight of pectin extracted from apple peel and pomace ranged between (576.02-723.34) g, the equivalent weight of apple peels and pomace (red, yellow, green, pomace),were (723.34,691.32,576.02, 671.12) respectively. The results of this study are close to the equivalent weight of pectin extracted from other fruits, where [37] indicated that equivalent weight of banana peels reached between (738.08- ,where they )751.57) g, while [38], indicated that equivalent weight for orange peels pectin was ranged (515-294.11), whearase [39] they indicated that the equivalent weight of mango peel pectin is (895.00) g (713.99-485.64 g ) . The equivalent weight is an indicator of the ability of the pectin to form a gel, as the higher the equivalent weight or the molecular weight of the pectin increases its ability and ability to form a gel, as indicated by [40].

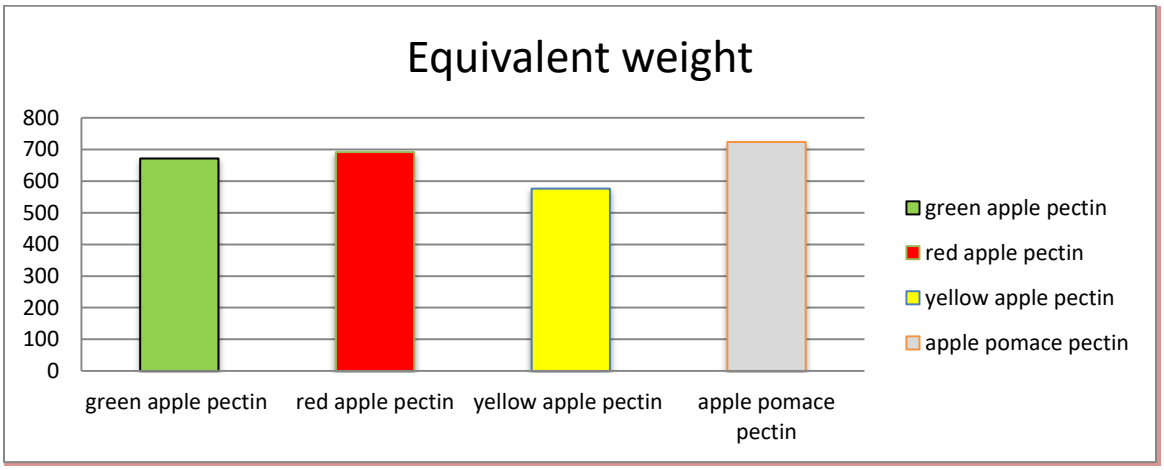



Figure (4) the equivalent weight of pectin

**9.3.4.**

**methoxyl content**

Figure (5) shows the content of methoxyl extracted from pectin, which ranged between (4.41-7.21)%, , the methoxyl content of apple peels and pomace (red, yellow, green, pomace) were (7.21,5.83, 4.41, 5.11) % respectively, the results of this study is slightly higher than what was found by [18 ] where they indicated that the content of methoxyl in apple pectin was 3.7%, and the results of this study are within limits of pectin quality standards (IPPA) which determined the methoxyl content of pectin between 2.5-7.8%, The results of this study are close to the methoxyl of pectin extracted from other fruits, where [41] have found that the methoxyl content of banana peels was 6.09% and in mango peels was 8.89%, while [38] they indicated that methoxyl content in pectin of dragon fruit ranged between 2.98-4.34%. The results also showed that there are differences between the findings of this study and what was mentioned in the previous studies, and this is due to many reasons, some of which were previously mentioned, in addition to the type of acid used in extracting, type of apple peel , in

addition to the fact that the type of apple peel studied is imported and is affected by shipping and storage periods and storage and display conditions, etc., which affect the nature and properties of pectin.

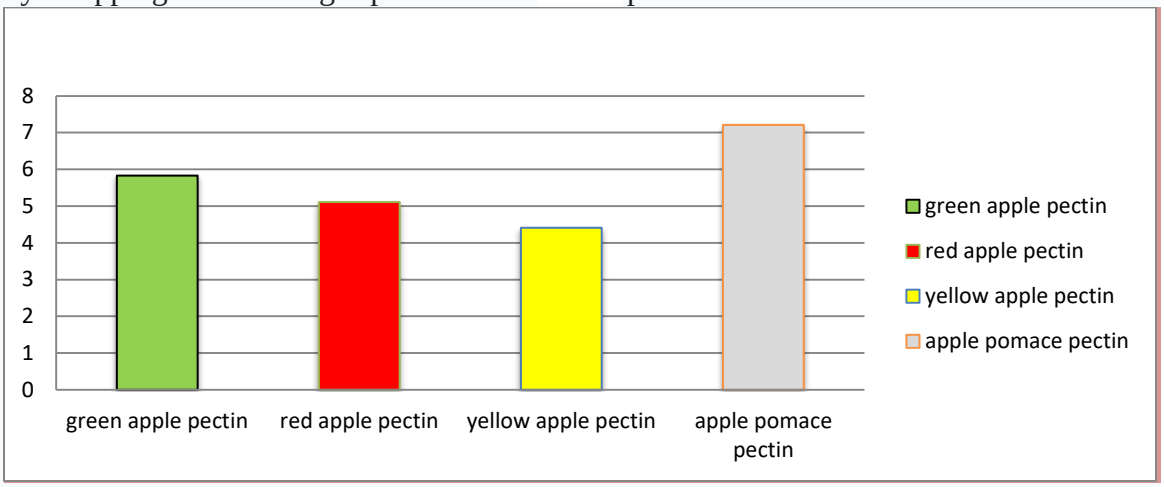
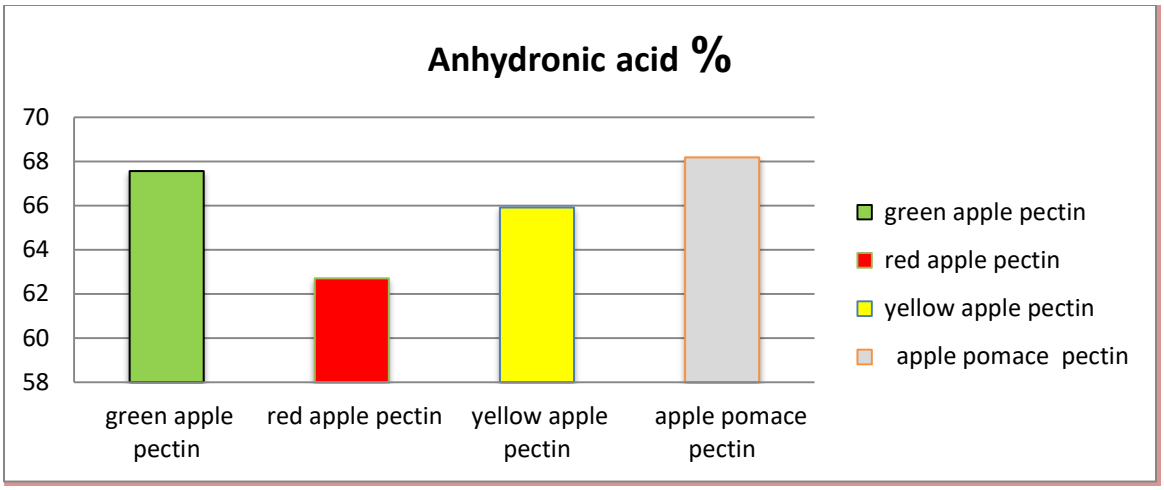



Figure (5) Content of methoxyl in pectin

**9.3.5.**

**Anhydronic acid content**

Anhydronic acid is an important factor in the determination of pectin quality as it indicates the suitability of pectin for use in jams, jellies, etc. Figure (6) showed the content of anhydronic acid in the pectin of apple peels and pomace, which ranged between (62.70-68.18)%, the anhydronic acid content of apple peels and pomace (red, yellow, green, pomace) were (62.70, 65.91, 67.56, 68.18)%, respectively. The results of this study are slightly less than what was found by [2] where they found that the content of anhydronic acid in apple pomace pectin was 76.80%. The results of this study are also somewhat similar to the content of anhydronic acid in the pectin of other fruit peels, where it was concluded that [42] , [43] that the content of anhydronic acid in the pectin of unripe banana peels is between (34.56-66.67)% and (56.67)%, respectively. While [44] found that the content of anhydronic acid in the papaya peels reached (69.97%)%. The pectin content of anhydronic acid is an indication of the degree of purity of pectin, according to what was specified by the , which indicates that the content of pectin from this acid is not less than 65% food chemical codex,1996. The content of pectin is from anhydronic acid , and if it is less than that, this is evidence of the impurity of the extracted pectin and the presence of some impurities such as proteins, starch, sugars [38].




Figure( 6) anhydronic acid in pectin

**9.3.6.**

**Degree of esterification**

Figure (7) shows the degree of esterification of pectin extracted from apple peel and pomace, as it was (34.11, 37.46, 33.69 , 58.15)% for (red, yellow, green, and pomace) respectively, The results of this study are identical to what was reached by [18]which found that the degree of esterification of pectin extracted from apple peels was 33.44%, It is also less than the results reached by [ 34] where he was found that the degree of esterification of pectin extracted from apple pomace is 72.40 and 56.9%, respectively. As for the degree of esterification of pectin extracted from the peels of other fruits, it ranged in the peels of sweet fruits and soybeans (54-77) and (56-60%), respectively, according to what was found by [45] [46], While [47] concluded that the degree of esterification of pectin in lemon pomace is 70.39%. The difference in the degree of esterification may be attributed to the difference in the type used, the conditions and methods of extraction and sedimentation, as well as the conditions and period of shipment, storage, display and others. It is the values of the degree of esterification that determine the ability of pectin to form a gel [48].

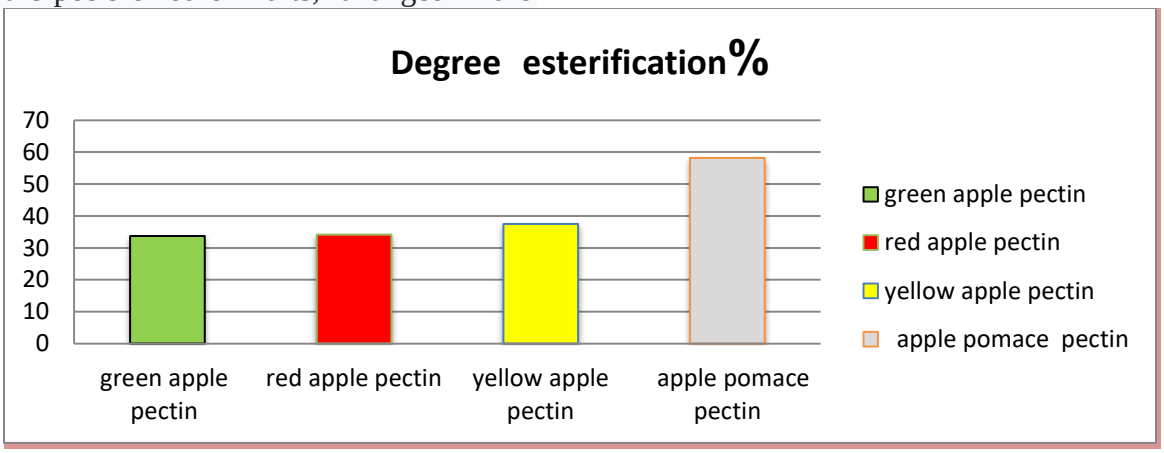



Figure (7) The degree of esterification in pectin

**9.4.**

**The physicochemical properties of yoghurt with added pectin**

**9.4.1.Moisture percentage**

The results shown in Table (2) show the percentage of moisture in yoghurt with pectin added at a concentration of 0.1% are the treatments A1,B1.C1,D1 while the treatments to which pectin was added at a concentration of 0.3% A2,B2,C2,D2. The treatments to which pectin was added at a concentration of 0.1% contained a moisture percentage of (86.49, 86.99, 86.80 and 87.31)%, respectively, As for the results of the transactions to which pectin was added by 0.3%, were (87.86, 87.62, 87.21 and 87.23%), respectively for the first day. As the control treatment on the first day was (88.80)%, where a high percentage of moisture was noticed, and this result was close to what was found [48] for fat-free yoghurt amounting to 88.10%, and the reason for this increase may be due to the lack of total solids due to reduction in fat, this is consistent with what was confirmed by [49] who indicated that reducing the fat leads to a high percentage of moisture in the yoghurt. After 7 days of storage, the results of the control treatment were (88.61), as for the treatments to which pectin was added at a concentration of 0.1, they were (86.88, 86.59, 86.72 and 87.21)%, respectively, as for the treatments to which pectin was added at concentration of 0.3%, they were (87.34, 87.02, 87.17, and 87.13)%, respectively**.** After 14 days of storage, the results of the control treatment were (88.42)%, as for the treatments to which pectin was added at a concentration of 0.1%, they were (87.02, 86.47, 86.19 and 87.54) %, respectively. As for the treatments to which pectin was added at a concentration of 0.3%, they were (87.17, 87.14, 87.11, and 87.01), respectively. The reason for the decrease in moisture may be due to the rate of evaporation and this is consistent with what was found by [50] who which indicated a decrease in the moisture content of yoghurt from 84.78 to 84.65% during cold storage for 15). The results of this study showed that there were no significant differences ($p \leq 0.05$) in moisture between the different treatments.

Table (2) Chemical composition of yoghurt with added pectin

| **Ingredients %** | | | | | **yoghurt (day)** | **Treatment** | |
|---|---|---|---|---|---|---|---|
| **Ash** | **Carbohydrate** | **fat** | **Protein** | **Moisture** | | | |
| **0.54** | **6.01** | **0.190** | **4.46** | **88.80** | **1** | **G+** | |
| **0.76** | **5.91** | **0.221** | **4.49** | **88.61** | **7** | | |
| **0.79** | **6.02** | **0.230** | **4.54** | **88.42** | **14** | | |
| **0.54** | **8.08** | **0.174** | **4.71** | **86.49** | **1** | **A1 0.1 %** | **pectin extracted from apple green peels** |
| **0.71** | **7.33** | **0.185** | **4.89** | **86.88** | **7** | | |
| **0.80** | **7.03** | **0.194** | **4.95** | **87.02** | **14** | | |
| **0.67** | **6.33** | **0.171** | **4.96** | **87.86** | **1** | **A2 0.3 %** | |
| **0.75** | **6.65** | **0.179** | **5.08** | **87.34** | **7** | | |
| **0.81** | **6.68** | **0.199** | **5.14** | **87.17** | **14** | | |
| **0.59** | **7.60** | **0.159** | **4.66** | **86.99** | **1** | **B1** | **p e c t i n** |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.63 | 7.89 | 0.186 | 4.70 | 86.59 | 7 | 0.1 % | |
| 0.79 | 7.78 | 0.212 | 4.74 | 86.47 | 14 | | |
| 0.60 | 6.55 | 0.162 | 5.06 | 87.62 | 1 | B2 0.3 % | |
| 0.71 | 7.00 | 0.159 | 5.11 | 87.02 | 7 | | |
| 0.74 | 6.75 | 0.171 | 5.19 | 87.14 | 14 | | |
| 0.50 | 7.81 | 0.170 | 4.72 | 86.80 | 1 | C1 0.1 % | pectin extracted from apple green peels |
| 0.58 | 7.77 | 0.179 | 4.75 | 86.72 | 7 | | |
| 0.71 | 8.10 | 0.168 | 4.83 | 86.19 | 14 | | |
| 0.56 | 7.19 | 0.202 | 4.83 | 87.21 | 1 | C2 0.3 % | |
| 0.70 | 7.01 | 0.198 | 4.92 | 87.17 | 7 | | |
| 0.81 | 6.84 | 0.221 | 5.01 | 87.11 | 14 | | |
| 0.56 | 7.33 | 0.182 | 4.61 | 87.31 | 1 | D1 0.1 % | Pectin from apple pomace |
| 0.69 | 7.25 | 0.171 | 4.67 | 87.21 | 7 | | |
| 0.75 | 6.82 | 0.180 | 4.71 | 87.54 | 14 | | |
| 0.60 | 7.09 | 0.208 | 4.87 | 87.23 | 1 | D2 0.3 % | |
| 0.73 | 6.99 | 0.200 | 4.95 | 87.13 | 7 | | |
| 0.81 | 6.92 | 0.224 | 5.03 | 87.01 | 14 | | |
| 0.229 * | 1.82 * | 0.152 * | 0.627 * | 4.59 NS | | | LSD |
| .(P≤0.05) * | | | | | | | |

**9.4.2.Protein percentage**

Table (2) shows the percentage of moisture in yoghurt with pectin added at a concentration of 0.1% are the treatments (A1,B1.C1,D1) while the treatments to which pectin was added at a concentration of 0.3% are (A2,B2,C2,D2). The treatments to which pectin was added at a concentration of 0.1% contained protein percentage of (4.71, 4.66, 4.72 and 4.61)%, respectively, As for the results of the transactions to which pectin was added by 0.3%, were (4.96, 5.06, 4.83 and 4.87%), respectively for the first day. As the control treatment on the first day was (4.46)%. While After 7 days of storage, the results of the control treatment were (4.49), as for the treatments to which pectin was added at a concentration of 0.1, they were (4.89, 4.70, 4.75 and 4.67)%, respectively, as for the treatments to which pectin was added at concentration of 0.3%, they were (5.08, 5.11, 4.92, and 4.95)%, respectively. This result was higher than what was found by [51 ] , who indicated that the protein content of yoghurt increased from 4.89 to 4.92 during the storage period of 15 days , Also, the results of the study agree with what was found by [52]. After 14 days of storage, the results of the control treatment were (4.54)%, as for the treatments to which pectin was added at a concentration of 0.1%, they were (4.95, 4.74, 4.83 and 4.71) %, respectively. As for the treatments to which pectin was added at a concentration of 0.3%, they were (5.14, 5.19, 5.01, and 5.03), respectively. These results were higher than what was found by [50], who indicated a high percentage of protein in garlic-infused yoghurt treatments from 4.76% to 4.80% immediately after processing at the end of the 15-day storage period, Also, The results of this study showed that there were significant differences ($p \leq 0.05$) in the percentage of protein between the treatments.

**9.4.3.Ash percentage**

Table (2) shows the percentage of ash in yoghurt with pectin added at a concentration of 0.1% for treatments (A1,B1.C1,D1) and the treatments to which pectin was added at a concentration of 0.3% are (A2,B2,C2,D2). The treatments to which pectin was added at a concentration of 0.1% contained protein percentage of (0.54, 0.59, 0.50 and 0.56)%, respectively, As for the results of the transactions to which pectin was added by 0.3%, were (0.67, 0.60, 0.56 and 0.60%), respectively for the first day. As the control treatment on the first day was (0.54)%. While After 7 days of storage, the results of the control treatment were (0.76), as for the treatments to which pectin was added at a concentration of 0.1, they were (0.71, 0.63, 0.58 and 0.69)%, respectively, as for the treatments to which pectin was added at concentration of 0.3%, they were (0.75, 0.71, 0.70, and 0.73)%, respectively. After 14 days of storage, the results of the control treatment were (0.79)%, as for the treatments to which pectin was added at a concentration of 0.1%, they were (0.80, 0.79, 0.71 and 0.75) %, respectively. As for the treatments to which pectin was added at a concentration of 0.3%, they were (0.81, 0.74, 0.81, and 0.81), respectively. These percentages are somewhat close to what was found by [53], [54] who indicated that the percentage of ash in the yoghurt made from whole milk was 0.68% and 0.70%, respectively. Also the results were similar to what was found by [55] in the fat-free yoghurt. The results of this study showed that there were significant differences ($p \leq 0.05$) in the percentage of ash between the treatments.

**9.4.4.fat percentage**

Table (2) shows the percentage of fat percentage in yoghurt with pectin added at a concentration of 0.1% for treatments (A1,B1.C1,D1) and the treatments to which pectin was added at a concentration of 0.3% are (A2,B2,C2,D2). The treatments to which pectin was added at a concentration of 0.1% contained protein percentage of (0.174, 0.159, 0.170 and 0.182) respectively, As for the results of the transactions to which pectin was added by 0.3%, were (0.171, 0.162, 0.202 and 0.208%), respectively for the first day. As the control treatment on the first day was (0.190)%. as it is noted from the results that the percentage of fat of yoghurt treatments with pectin added to it decreased compared to control treatment (G+), due to the increase in the concentration of solids by adding fat substitutes to fat-free yoghurt milk. After 7 days of storage, the results of the control treatment were (0.221), as for the treatments to which pectin was added at a concentration of 0.1, they were (0.185, 0.186, 0.179 and 0.171)%, respectively, as for the treatments to which pectin was added at concentration of 0.3%, they were (0.179, 0.159, 0.198, and 0.200)%, respectively. It is also noted from the results that the percentage of fat of yoghurt treatments with pectin added to it was lower compared to control treatment (G+), due to the increase in the concentration of solids by adding pectin extracted from apple peels and pomace to fat-free yoghurt, and these results are close to what was reached by [56] for fat-free yoghurt. After 14 days of storage, the results of the control treatment were (0.230)%, as for the treatments to which pectin was added at a concentration of 0.1%, they were (0.194, 0.212, 0.168 and 0.180) %, respectively. As for the treatments to

which pectin was added at a concentration of 0.3%, they were (0.199, 0.171, 0.221, and 0.224), respectively. These results agree with what was found by[55], and also agree with what was found by[56], who indicated that the reason for the increase in the percentage of fat is the decrease in the percentage of moisture, which led to an increase in the percentage of total solids Including fat. The results of this study showed that there were significant differences ($p \leq 0.05$) in the percentage of protein between the treatments.

**9.4.5.Carbohydrate percentage**

The results shown in table (2) show the percentage of carbohydrate in yoghurt with pectin added at a concentration of 0.1% for treatments (A1,B1.C1,D1) and the treatments to which pectin was added at a concentration of 0.3% are (A2,B2,C2,D2). The treatments to which pectin was added at a concentration of 0.1% contained protein percentage of (8.08, 7.60, 7.81 and 7.33)%, respectively, As for the results of the transactions to which pectin was added by 0.3%, were (6.33, 6.55, 7.19 and 7.09%), respectively for the first day. As the control treatment on the first day was (6.01)%. After 7 days of storage, the results of the control treatment were (5.91), as for the treatments to which pectin was added at a concentration of 0.1, they were (7.33, 7.89, 7.77 and 6.25)%, respectively, as for the treatments to which pectin was added at concentration of 0.3%, they were (6.65, 7.00, 7.01, and 6.99)%, respectively. These result is close to what was indicated by [55] when adding inulin to yoghurt. It is also noted that the percentage of carbohydrates decreased with the progression of the storage period for all treatments, so the values, after 14 days of manufacturing, were for control treatment (6.02), as for yoghurt treatments with added pectin at a concentration of 0.1% were (7.03, 7.78,8.10, 6.82) ), respectively, As for the treatments to which pectin was added at a concentration of 0.3%, they were (6.68, 6.75, 6.84, and 6.92)%, respectively. The reason for this decrease is due to the activity of the starter bacteria, which converts the sugar lactose into lactic acid, and this is consistent with what was found by [ 57] which indicated a decrease in the percentage of carbohydrates in yoghurt from 4.42 % to 4.07 % during the storage period of 25 days. Also it agrees with what found by [58] , [59] , [60] in the percentage of carbohydrates at the end of the storage period. The results of this study showed that there were significant differences ($p \leq 0.05$) in the percentage of carbohydrate between the treatments.

**9.5.sensory evaluation**

Table (3) shows the results of sensory evaluation of yoghurt samples for the previously mentioned treatments, and it is clear from them that the results of sensory evaluation of yoghurt supplemented with pectin are superior to the treatment of positive control G+ in all sensory evaluation characteristics because of the active role of pectin in imparting good color, taste, flavor and texture qualities . In general, the results showed that pectin has a clear role in improving the sensory qualities of yoghurt, where the positive control treatment obtained the highest total score of 82.39%, while the pectin treatment with an addition of 0.1% obtained the highest total score of 89.48%, and this is consistent with what was found by [61] who indicated that the yoghurt with

inulin added has good sensory qualities, it also agrees with what was found by [56] for yoghurt free of fat to which some fatty alternatives have been added. As for the characteristic of taste and flavour, it is noted that the scores given to the pectin treatments were higher compared to the scores given in the positive control treatment, meaning that the addition of pectin had improved the taste and flavor characteristics. This is in agreement with what was found by [62] , which indicated that inulin gives yoghurt a creamy oral taste due to its ability to bind water and interfere with protein aggregates. As for the results of evaluating the character of texture, it is clear from them that the yoghurt with added pectin at a concentration of 0.3% obtained the highest degrees of texture and was closer to the treatments of added pectin with a concentration of 0.1% compared to the degrees given to the texture character of yoghurt with the treatment of positive control. This is consistent with what it was found by [63] who indicated that the addition of inulin to fermented dairy products gives texture similar to the texture that gives it fat. It is also noted from the table that the degrees given to the acidity of the yoghurt treatments with pectin added to it increased, which in some of the addition percentages exceeded even the degrees of the positive control treatment immediately after manufacturing. As for the trait of appearance, it is clear that the scores given to the pectin treatments in this trait are higher compared to the scores given to the same trait of yoghurt as the positive control treatment. It is noted from the table that the sensory evaluation scores declined for all the studied traits with the progression of storage. It is also noted that there are significant differences ($P<0.05$) within one trait during storage, and it gave the best acceptance to the consumer at a concentration of 0.3%, and this is consistent with what was reached by [64] which gave the best concentration at 0.2% compared to a concentration of 0.6 % in okra pectin.

Table( 3) Sensory evaluation of yoghurt with added pectin

| **Sensory evaluation** | | | | | | **Yoghurt (day)** | **Treatment** | |
|---|---|---|---|---|---|---|---|---|
| **Degree 100 average** | **packa 5° ging** | **10° acidity** | **10° exterior** | **texture 30°** | **flavor 45°** | | | |
| **82.39** | **5.00** | **9.05** | **8.00** | **23.12** | **37.22** | **1** | **G+** | |
| **72.94** | **5.00** | **8.31** | **7.80** | **20.42** | **31.41** | **7** | | |
| **65.86** | **5.00** | **6.22** | **7.50** | **19.22** | **27.92** | **14** | | |
| **84.5** | **5.00** | **9.25** | **8.83** | **24.00** | **37.42** | **1** | **A1 0.1 %** | **pectin extracted from red apple peels** |
| **79.03** | **5.00** | **8.77** | **8.03** | **22.02** | **35.21** | **7** | | |
| **71.56** | **5.00** | **8.04** | **8.00** | **21.88** | **28.64** | **14** | | |
| **86.94** | **5.00** | **9.02** | **8.92** | **25.00** | **39.00** | **1** | **A2 0.3 %** | |
| **79.41** | **5.00** | **8.00** | **8.15** | **22.14** | **36.12** | **7** | | |
| **72.47** | **5.00** | **7.00** | **8.00** | **20.84** | **31.63** | **14** | | |
| **87.79** | **5.00** | **8.71** | **9.15** | **26.22** | **38.71** | **1** | **B1 0.1** | **pectin extr** |
| **78.09** | **5.00** | **7.74** | **9.00** | **24.04** | **32.31** | **7** | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 74.41 | 5.00 | 8.00 | 8.12 | 22.87 | 30.42 | 14 | % | |
| 87.73 | 5.00 | 9.15 | 9.25 | 27.34 | 36.99 | 1 | B2 0.3 % | |
| 85.16 | 5.00 | 8.61 | 8.54 | 27.00 | 36.01 | 7 | | |
| 77.01 | 5.00 | 7.98 | 8.21 | 24.66 | 31.16 | 14 | | |
| 89.48 | 5.00 | 7.33 | 9.66 | 28.08 | 39.41 | 1 | C1 0.1 % | pectin extracted from green apple peels |
| 82.99 | 5.00 | 8.02 | 9.00 | 26.42 | 34.55 | 7 | | |
| 76.25 | 5.00 | 7.77 | 8.32 | 22.64 | 32.68 | 14 | | |
| 82.54 | 5.00 | 8.40 | 9.84 | 23.32 | 35.98 | 1 | C2 0.3 % | |
| 76.24 | 5.00 | 8.00 | 8.06 | 22.66 | 32.52 | 7 | | |
| 72.98 | 5.00 | 7.88 | 7.08 | 22. 02 | 31.00 | 14 | | |
| 83.7 | 5.00 | 9.12 | 8.22 | 28.00 | 33.36 | 1 | D1 0.1 % | Pectin from apple pomace |
| 78.32 | 5.00 | 8.33 | 8.00 | 25.94 | 31.05 | 7 | | |
| 75.68 | 5.00 | 7.41 | 7.55 | 25.50 | 30.22 | 14 | | |
| 85.97 | 5.00 | 8.66 | 9.33 | 27.00 | 35.98 | 1 | D2 0.3 % | |
| 79.81 | 5.00 | 8.92 | 8.04 | 25.71 | 32.14 | 7 | | |
| 77.13 | 5.00 | 8.00 | 8.00 | 24.41 | 31.72 | 14 | | |
| 8.03 * | 0.4 NS | 1.26 * | 1.85 * | 4.94 * | 6.79 * | LSD | | |
| .(P≤0.05) * | | | | | | | | |

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