Effect of Jerusalem artichoke (*Helianthus tuberosus*) extract as an alternative to fat on the quality of low fat Yoghurt

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Abstract

The effect of adding different concentrations of Jerusalem artichoke (Helianthus tuberosus) extract on the quality of low-fat yoghurt was studied. 10, 15, 20 ml of the Jerusalem artichoke (Helianthus tuberosus) extract was added to the pasteurized liquid milk contain 0.1% milk fat to purpose of giving different levels of inulin/ µg (each milliliter from Jerusalem artichoke (Helianthus tuberosus) extract contains 21 µg of inulin). The yoghurt samples were compared with the control sample produced from whole fat milk. The content of total solids in milk was adjusted to 14% by adding skim milk powder. After storage periods 1, 7, and 15 days, the chemical-physical composition of the yoghurt samples, such as pH, titratable acidity, syneresis (whey separation), the amount of acetaldehyde, and volatile fatty acids. The sensory characteristics of the samples were also evaluated during the same storage periods. It was found that the addition of Jerusalem artichoke extract containing more than 210 µg caused in increased separation of whey and consistency. The values of acetaldehyde, PH and titratable acidity were not affected by adding the Jerusalem artichoke extract. volatile fatty acid levels were affected negative. In the case of sensory evaluation of yogurt. The addition of Jerusalem artichoke extract resulted in the retention of the sensory quality grades, where the treatment control was highest, and the lowest grade was obtained in the yoghurt samples containing 420 µg of inulin. Overall, the quality characteristics of the yoghurt containing 210 µg inulin was similar to the quality characteristics of the control like yoghurt made from whole milk.

Key Words: Helianthus tuberosus extract, Alternative fat, Low- Fat yoghurt, Storage.
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تأثير مستخلص الالمازة (هيليانثوس توبيروسوس) كبديل للدهون على نوعية اليوغرت قليل الدهن

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الخلاصة

تم دراسة تأثير إضافة تراكيز مختلفة من مستخلص الالمازة (هيليانثوس توبيروسوس) على نوعية اليوغرت قليل الدسم. تم إضافة 10، 15، 20 مل من هذا المستخلص إلى الحليب السائل المبستر الذي يحتوي على 0.1٪ من دهن الحليب، لغرض تجهيز مستويات مختلفة من الإينولين/ ميكروغرام (كل ملليلتر من مستخلص الالمازة يتضمن على 21 ميكروغرام من الإنولين). تم مقارنة عينات اليوغرت مع عينة السيطرة المنتجة من الحليب كامل الدهن. كما تم تعديل محتوى المواد الصلبة الكلية في الحليب إلى 14٪ بإضافة مسحوق الحليب الفرز. وبعد فترات الخزن 1، 7 و15 يوم، تم تقييم التركيب الفيزيوكيميائي لعينات اليوغرت، مثل الاس الهيدروجيني، الحموضة التسحيحية، نضح شرش اللبن، وكمية الأسيتالديهايد، والأحماض الدهنية المتطايرة. كما تم تقييم الخواص الحسية للعينات خلال فترات الخزن نفسها. وقد وجد أن إضافة مستخلص الالمازة المحتوي على أكثر من 210 ميكروغرام تسبب في زيادة كل من فصل الشرش وقوام اللبن. ولم تتأثر قيم الأسيتالديهيد، والاس الهيدروجيني والحموضة التسحيحية بإضافة مستخلص الالمازة. في حين تأثرت مستويات الأحماض الدهنية المتطايرة سلبيا. وفي حالة التقييم الحسي لليوغرت، فان إضافة مستخلص الالمازة أدت إلى الحفاظ على درجات الجودة الحسية، إذ كانت معاملة السيطرة أعلى، وتم الحصول على أدنى درجة في عينات اللبن التي تضمنت على 420 ميكروغرام من الإينولين. وبصفة عامة، وكانت خصائص جودة اليوغرت المحتوي على 210 ميكروغرام إنولين مشابهة لخصائص نوعية معاملة السيطرة مثل اليوغرت المصنع من الحليب كامل الدسم.

الكلمات المفتاحية: مستخلص الالمازة، بديل الدهن، يوغرت قليل الدسم، الخزن

Introduction

Recently, the relationship between fat consumption and heart disease has been accepted and recommended by nutritionists to reduce the consumption of animal fat (1). Increased consumption of dairy products low or fat free and increased recognition of health benefits, and health problems of consumers (1, 2). The Fat in milk has an important role in development of the texture, flavor and color in dairy products. Fat reduction can cause some defects in yogurt and non-fat ice cream such as lack of flavor, weak body and poor texture (3). Although it is possible to manufacture low or non-fat dairy products for many years, the use of lipid replacers in the manufacture of these products has been recently used. Fat replacers, which reduce the caloric value of food, can be used to treat or solve some physical and organoleptic problems caused by low fat levels in final products. Fat replacers consist of a mixture that includes originated fat substitutes, proteins, carbohydrates and axis fats or their combinations (3). Inulin is a carbohydrate-derived or dietary fiber that is an alternative to fat as well as its ability to form gelling with water. It is also a functional food because of its prebiotic properties, (4). It is not digested in the small intestine, but it is fermented in the colon by lactic acid bacteria such as yogurt starter cultures. inulin promotes the growth of healthy bacteria and enhances absorption of calcium, magnesium and immune functions, and reduces the level of cholesterol and serum lipids (5). Furthermore, the fermentation of inulin may stimulate the formation of short-chain fatty acids such as acetate, propionate, butyrate and the latter being the preferred energy substrate for colonocytes (6). Inulin, in water-based foods such as dairy products, when used as a fat replacer, gives a fat-like mouth feel and texture (7). The objective of this study was to investigate the possibility of using Jerusalem artichoke extract in the manufacture of low-fat yogurt, and the effect of addition of inulin on chemical, physical and sensory properties of yoghurt during storage.

Materials and Methods

- **Raw Cow Milk**: obtained from the lab of Abu Gharib and the total solids were calculated to 14% weight/volume.
- **Skim Milk Powder**: It is the French-made Regilai type, the company Saint Martin Belle, purchased from local markets.
- **Preparation of Jerusalem artichoke extract powder**: Jerusalem artichoke tubers were obtained from the local markets, soaked with water to be cleaned well, cut into strips and then hung in yarns made of jute (stly) and placed in a sterile dry place temperature of 40-45 ºC until it is fully dried and reach Moisture ratio 5%. The slides were grinding with an electric mixer to obtain the powder (8).
- **Preparation of Jerusalem artichoke extract**: In accordance with the method reported by (9) and for get Jerusalem artichoke extract, 11 g of Jerusalem artichoke powder was reconstituted in 400 ml of sterilized water and dissolved well to obtain the extract. The heat continues at 50 °C for 4 hours with continuous mix the suspension solution, filtering the solution with a cotton cloth to remove the fibers and get a clear solution.
- **Determination of inulin in the Jerusalem artichoke extract**: This was done according to (10) by using high performance liquid chromatography (H.P.L.C) device, Type a fast liquid chromatograhic (F.L.C) American origin. The concentration of inulin in the extract was calculated according to the formula:

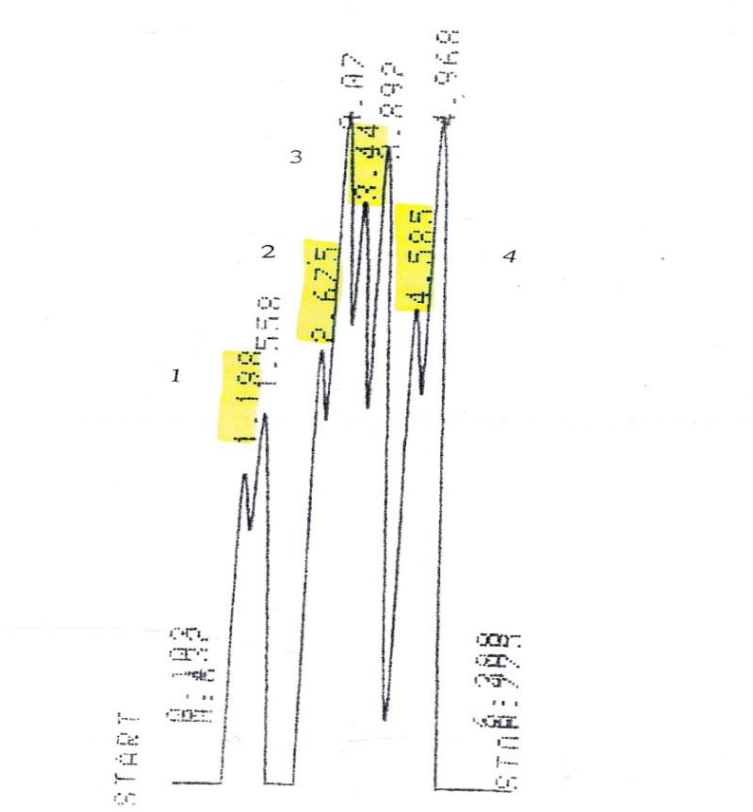
Concentration of sample µg/ ml= sample area (µv)/ standard inulin area(µv)× standard inulin concentration µg / ml× dilution factor

- **Starter culture**: It was obtained from Dairy Laboratory in College Agriculture-University of Baghdad. The mixture containing of *Streptococcus thermophilus* & *Lactobacillus delbrueckii ssp. bulgaricus* Lyophilized.

- **Yoghurt Manufacture:** Four samples of milk were identical in manufacture and repeat according to (11). The sample of whole fat milk (3.1%) as standard control, the low fat milk samples (0.1%) designed to three parts as shown in Table (1). The raw milk separated by separator, Electrem, France at 40 °C. The milk was mixed with skim milk powder in varying proportions and mixed by using electric mixer , Ultra Turrax (IKA, Merck, Germany) to dissolve that milk powder. The same mixtures pasturized at 90° C for 5 minutes and chilled to 47°C. Then added different levels from the Jerusalem artichoke extract or in different sizes (ml) to get different weights of inulin. Then mix the ingredients well, The prepared liquid was inoculation by using 2% of the Starter culture (weight/ volume), distributed in plastic cups, capacity 200 g, incubated at 43±1 °C until reaching pH 4.7. All milk samples were kept at room temperature 21 °C for 30 minutes, after which samples were placed in the refrigerator until the chemical tests were conducted. Other samples were stored for 1, 7, 15/ day at 4 °C, samples were taken for chemical and biological testing.

Table (1) Design of the experiment

Samples	Milk fat (%)	content of inulin (µg) in Jerusalem artichoke extract (ml)	skim milk powder (%)
A (control)	3.1	0	2
B	0.1	210 µg / 10 ml	4
C	0.1	315 µg / 15ml	3
D	0.1	420 µg/ 20 ml	2



- **Chemical Composition of Raw Milk:** Determination of total solids, protein and ash: Those tests were conducted as reported in (12). While determination of Lactose Sugar was done according to (13). Determination of Fat and Titratable aciity was done according to (14). Also the pH testing That done by pH meter according to (Pye Unicom, England). The testing of consistency was perform by using a penetrometer scale in a company SUR BERLIN PNR 6. Estimation of the separation

whey perform according to (15). Estimation of free fatty acids perform that according to (16) while estimation of acetaldehyde made according to (17).

- **Statistical Analysis**: Data analysis was performed by using ANOVA and application the SAS program (17) and the data were tested according to the Duncan test (18). The averages were compared with the probability level of ($p<0.05$).
- **Sensory Evaluation**: The sensory properties of the yoghurt samples were evaluated according to the questionnaire form (19). The samples were evaluated by a number of judges specialized in milk and dairy products, in University of Baghdad according to form (1).

Fig. (1) Sensory evaluation form for properties of yoghurt samples

Properties	High class	Degree granted
Taste and flavor	40	
Texture & consistency	20	
Colour & appearance	20	
general acceptability	20	
total	100	

Results and Discussion

Table 2 shows the chemical composition of the milk samples examined. The total solid contents of the sample ranged between 13.47- 13.67%, and the total protein, lactose values increased with the addition of skim milk powder.

Table (2) Chemical composition of raw milk (%) used in the manufacture of yoghurt samples

Parameter / Samples	Total solid	Fat	protein	lactose	ash
A	13.67 ± 0.08 a	3.1 ± 0.01 a	4.06 ±0.20 a	5.48± 0.04c	0.88±0.00c
B	13.48±0.20a	0.1±0.01c	3.84± 0.18a	7.04 ±0.26c	1.0±0.0b
C	13.47±0.07a	0.1±0.01c	3.94±0.19a	6.25 ±0.03b	1.06±0.01b
D	13.51±0.07a	0.1±0.01c	3.98±0.20a	5.50 ± 0.12a	1.22±0.04a

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

Table 3 shows the effect of storage periods on pH in yoghurt samples with different concentrations of Jerusalem artichoke extract. The pH values were between 4.19- 4.40 at the first day, 3.98- 4.27 after fifteen day. When used the Jerusalem artichoke extract as an alternative to fat, there was no significant effect on the pH values at the probability level ($p<0.05$), Confirmed, (20), that no lipid as an alternative for fat has no any negative effect on the change in the activity of the yogurt bacteria. It is also noted that the values of pH during the storage of yoghurt samples, decreased slightly, and insignificant at probability level ($p<0.05$). This may be due to the effect of storage temperature on the activity of starter bacteria during storage.

Table (3) The effect of the storage period on pH in the yoghurt sample added to it different concentrations from Jerusalem artichoke extract

Samples	Storage periods/ day			General average/ sample
	1	7	15	
	average ± standard error			
A	4.40±0.26a	4.37±0.31a	4.27±0.15a	4.34 ± 0.15a
B	4.19±0.46a	4.11±0.36a	4.04±0.22a	4.11±0.13a
C	4.19±0.17a	4.13±0.05a	4.05±0.11a	4.12±0.09a
D	4.29±0.33a	4.06 ± 0.14	3.98±0.13a	4.11±0.11a
General average /Storage Periods	4.26±0.10a	4.16±0.13a	4.08±0.05a	

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Table 4 showed there was increase in tetratable acidity of the yoghurt samples during storage at significant level ($P<0.05$), but was not affected when the percentages of the Jerusalem artichoke extract differed significantly within the same storage period. The tetratable acidity of the day 15 was higher than the acidity of the samples during storage periods 1 and 7. The tetratable acidity in the (B) yoghurt samples containing 210 μg

of inulin per 10 ml in the Jerusalem artichoke extract was highest content from that other sample. This may be due to the addition of a high percentage of skim milk for this sample.

Table (4) Effect of the storage period on tetratable acidity (SH°) in the yoghurt samples added to them different concentrations of Jerusalem artichoke extract.

Samples	Storage periods / day			
	1	7	15	General average /sample/
	average ± standard error			
A	52.28±2.83e	57.88±0.65cd	62.22±0.40 ab	56.51±2.10c
B	57.15±2.80 cd	60.51±0.09 abc	63.77±0.44 a	61.14±1.24 a
C	55.09±0.60 de	58.88±0.56 bcd	62.43±0.13ab	59.54±1.37 ab
D	55.77±0.64 de	57.78±0.33 cd	62.29±0.95 ab	58.61±1.25cb
General average / Storage Periods	54.72±1.11c	58.76±0.45 b	62.74±0.35 a	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05.

Curd stability in yoghurt is one of its most important physical properties. The factors which influence curd stability are total solids and protein content, milk acidity and storage temperature, as well as the effect of heating, homogenization and activity of yogurt bacteria (22). Table (5) shows that the difference in the levels of the inulin in the extract has a significant effect on the consistency of yoghurt samples during all storage times at a probability level ($P<0.01$). Sample (B) had the lowest values of consistency during storage. While the standard yoghurt, sample (A) his content was higher than that of yoghurt sample (B), While the texture in yoghurt sample (C) which containing 210 µg per 10 ml from Jerusalem artichoke extract was higher. Also that table (5) shows a linear increase in consistency towards the reduced concentration of the Jerusalem artichoke extract and increase the percentage of skim milk powder added. The consistency level of the yoghurt sample (B) was lowest, that added 4% of the skim milk powder, and lowest level from inulin in the Jerusalem artichoke extract. Also notes a high level of consistency in the yoghurt sample (C). This may be the cause addition of the Jerusalem artichoke extract which contains 315 µg inulin and contains, skim milk powder 3%. Also was observed reducing at all yoghurt samples during storage periods, but this was not significant at ($P<0.05$).

Table (5) Effect of the storage period on the consistency (×0.1 mm) in the yoghurt samples has added different concentrations of the Jerusalem artichoke extract .

Samples	Storage periods / day			
	1	7	15	General average / sample/
	average ± standard error			
A	211.37±4.87 ab	201.71±12.94 ab	182.67±0.91 abcd	198.58±4.03 a
B	194.57±5.31 bcd	191.24±0.67 cd	186.86±0.75 d	190.89±1.98 b
C	218.70±3.67 a	213.08±1.04 a	202.94±3.52 ab	211.57±1.79 a
D	220.07±3.69 a	217.07±1.04 ab	209.06±2.70 abc	215.40±2.73 a
General average/ Storage Periods	211.17±4.48 a	205.77±4.20 a	195.38±3.68 a	

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One of the most important defects of yoghurt is the separation of whey. Table 6 show that the addition of Jerusalem artichoke extract to yoghurt caused increased rates of separation whey from yoghurt samples, during all storage periods. The lowest separation was in yoghurt sample (B), while the highest level separation was in yoghurt sample(D). This may be due to, low percentage of skim milk powder, also, because increase the amount additive of Jerusalem artichoke extract. It was also observed that the separation whey was decreased significantly during storage, in the standard yoghurt sample (A), at a significant level ($P<0.01$). This was confirmed by both (15, 23).

Table (6) Effect of the storage period on whey separation (g/25 g) in yoghurt samples which added to it different concentrations of the Jerusalem artichoke extract

Samples	Storage periods / day			
	1	7	15	General average/ sample/
	average ± standard error			
A	5.24±0.08c	4.94±0.11cd	4.44±0.12d	4.87±0.15b
B	4.96±0.07cd	4.19±0.04d	4.17±0.01d	4.33±0.15c
C	6.34±0.06b	4.32±0.66d	4.36±0.18d	5.00±0.45b
D	7.29±0.03a	5.56±0.22c	5.41±0.03c	6.08±0.38a
General average/ Storage Periods	6.10±0.37a	4.75±0.24b	4.59±0.18b	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

Yoghurt flavor consists of volatile ingredients and is also caused the degradation of some milk components when heating the milk. It was produced during fermentation of milk. One of the most important aromatic compounds in yoghurt was acetaldehyde (24). For optimal flavour in yogurt, the concentration of acetaldehyde must be between 23 and 41 mg/ kg yoghurt (25). Table (7) shows that after storage periods of 7 days and 15 days, was found highest rate of acetaldehyde in the sample that was free of inulin (A), at the probability level ($P<0.05$). These changes can be due to the effectiveness of the yogurt starters enzyme (alcoholdehydrogenase) in the relationship between acetaldehyde and ethanol (25). Also variation of acetaldehyde between yogurt samples during storage periods was observed (26). The researcher explained these variability in the concentration of volatile compounds such as calcitaldehyde, acetone and ethanol in all samples, despite similar manufacturing conditions. One of the causes of variability was the ease of acetaldehyde degradation to ethanol alcohol by the alcohol dehydrogenase enzyme which it produces by Str.thermophilus bacteria.

Table (7) Effect of the storage period on acetaldehyde (mg/ kg) in yoghurt sample with different concentrations of Jerusalem artichoke extract

Samples	Storage periods / day			
	1	7	15	General average/ sample
	average ± standard error			
A	7.48±0.32a	6.63±0.29bc	6.12±0.03cd	6.74±0.27a
B	6.21±0.07c	6.15±0.22c	5.42±0.28e	5.92±0.20bc
C	7.08±0.06ab	6.45±0.24bc	5.49±0.12de	6.34±0.30b
D	6.73±0.19bc	5.52±0.29de	5.37±0.05e	5.87±0.28c
General average/ Storage Periods	6.87±0.19a	6.18±0.189b	5.60±0.128c	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

Volatile free fatty acids are not the main component of yoghurt but they help to make yoghurt flavor balanced. These free fatty acids also contribute to flavor synergies with acetaldehyde (27). The addition of Jerusalem artichoke extract to yoghurt at different levels of inulin has an effect on the content of free fatty acids in the yoghurt. Table (8) shows presence increase volatile free fatty acids during storage periods of yoghurt samples. These increases contributed to a significant effect at the probability level ($P<0.01$). The increase in free fatty acids during storage may be due to the efficacy of yoghurt starter (22, 25).

Table (8) Effect the storage period on volatile free fatty acids (ml 0.1 N NaOH/ 100 g) in the yoghurt samples that added to it, different concentrations of Jerusalem artichoke extract

Samples	Storage periods / day			
	1	7	15	General average / sample/
	average ± standard error			
A	3.23±0.10bcde	3.51±0.18bc	4.09±0.01a	3.61±0.16a
B	3.40±0.10bcd	3.60±0.15b	4.20±0.30a	3.73±0.17a
C	3.00±0.08cde	3.52±0.15bcde	3.40±0.20bcd	3.26±0.10b
D	2.80±0.10e	2.89±0.01de	3.35±0.05bcd	3.01±0.11b
General average/ Storage Periods	3.12±0.10b	3.31±0.11b	3.76±0.16a	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

Tables (9, 10, 11, 12) explain the sensory properties of yoghurt samples. Table (9) shows the color and appearance values they were highest in the control sample(A), followed the yoghurt sample (B), which contains Jerusalem artichoke extract 210 µg of inulin, The addition of an increase in Jerusalem artichoke extract rates resulted in negative effects on color and appearance score values with increased storage periods and this happens in all yoghurt samples.

Table (9) Effect of storage periods on the quality of color and appearance characteristics of yoghurt samples

Samples	Storage periods / day			
	1	7	15	General average / sample/
	average ± standard error			
A	31.20±1.24a	27.70±1.33abc	27.40±0.81abc	28.76±0.76a
B	29.40±1.26ab	25.90±1.62bc	25.40±0.99bc	26.90±0.85ab
C	27.70±1.11abc	24.20±2.02cd	23.60±1.19cd	25.16±0.93b
D	25.80±1.14bc	20.70±1.47d	20.30±2.00d	22.26±1.07c
General average/ Storage Periods	28.52±0.71a	24.62±0.93b	24.17±0.85b	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

Table (10) shows presence significant differences in the body and tixture of yoghurt samples after storage periods 7 and 15 days compared with the first day from storage period. This may be due to addition of the extract as well as the effect of storage periods.

Table (10) Effect of storage periods on tixture and body quality of yoghurt samples

Samples	Storage periods / day			
	1	7	15	General average/ sample/
	average ± standard error			
A	13.70±0.37a	11.50±0.41bc	10.12±0.51def	11.89±0.49a
B	12.40±0.43b	10.60±0.29cde	9.30±0.30fgh	10.76±0.38b
C	11.20±0.33cd	9.90±0.29efg	8.50±0.15h	9.86±0.32
D	10.10±0.18def	8.80±0.33gh	5.90±0.64i	8.26±0.52d
General average/ Storage Periods	11.85±0.34a	10.20±0.27b	8.36±0.42c	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

The addition of Jerusalem artichoke extract influenced the taste and aroma scores of yoghurt samples. Table (11) illustrated decrease in taste and odor rates in all samples and after storage periods 7 & 15 days. Also there were significant differences observed In the same storage periods compared with the first day of storage.

Table (11) Effect of storage periods on taste quality and flavor of yoghurt samples

Samples	Storage periods / day			
	1	7	15	General average/ sample/
	average ± standard error			
A	15.60±0.62a	13.40±0.81bc	12.60±0.81bcd	13.86±0.52a
B	14.30±0.33ab	12.20±0.88cde	10.60±1.02def	12.36±0.59 b
C	12.60±0.43 bcd	10.40±0.36 ef	9.20±0.25 f	10.73±0.42c
D	11.10±0.53 def	9.20±0.37 f	6.80±0.66 g	9.03±0.55d
General average/ Storage Periods	13.40±0.45a	11.30±0.47 b	9.80±0.59c	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

Table (12) indicated to the general acceptance degree of yoghurt samples. The standard yoghurt sample (A) showed the highest levels, followed samples B, C and D which containing 210 µg, 315 µg and 420 µg of inulin, respectively. These differences showed significant differences at a potential level ($P<0.01$), especially in storage periods 7 and 15 compared to the first day of storage.

Table (12) Effect of storage periods on the general acceptability degree of yoghurt samples

Samples	Storage periods / day			
	1	7	15	General average/ sample
	average ± standard error			
A	14.30±±0.53a	12.10±0.67bc	11.30±0.58bcd	12.56±0.46a
B	13.0±0.47ab	11.50±0.59bcd	9.90±0.62def	11.46±0.45b
C	12.10±0.45bc	10.60±0.43cde	8.10±0.84fg	10.26±0.54c
D	11.50±0.74bcd	8.90±0.78efg	7.20±0.71g	9.20±0.61d
General average/ Storage Periods	12.72±0.35a	10.77±0.40b	9.12±0.48c	

Data with different letters indicate that they differ significantly from each other at a significant level of 0.05

This research concluded that the increase of Jerusalem artichoke extract (Containing inulin) in fat-free yoghurt had a negative effect in some of its physical properties. Such as, whey separation, consistency and organoleptic scores. However, yoghurt samples containing 210 µg of inulin showed similar characteristics to the control yoghurt containing 3% of milk fat. The best results were obtained by adding inulin to the fat-free yoghurt at 210 µg. The purpose for low-fat yoghurt production, the concentration of inulin used it at 210 µg and the higher concentrations of inulin should not be acceptable. There is also a tendency to use inulin and add it in order to manufacture of low-fat dairy products because of its potential to give beneficial effects for improve health.

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