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The Addition of Lemon Peel Powder Affects the Properties of Yogurt

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ABSTRACT

Lemon peels are a solid by-product produced during the industry and are often disposed of as agricultural waste. This research aims to take advantage of the lemon peels that are disposed of, as well as to raise the content of the yogurt from vitamin C, which works to raise immunity. It is known that milk and its products are poor in their content of vitamin C. In this research, the crushed lemon peel was added to the yogurt at different concentrations. (0.1, 0.2, 0.3%) to raise the content of vitamin C in the yogurt and it was incubated at different temperatures 30° and 45° C and the protein, fiber , calcium, sodium, iron and potassium were estimated. Antioxidants, viscosity, and pH were tracked during manufacturing, and samples incubated at 30 °C required a longer time during incubation to reach the required pH. The vitamin C content was higher in the samples incubated at 30°C, as was the case for the antioxidants. The protein content in the samples did not differ between the samples to which lemon peel was added and the control ones, as well as between the samples incubated at 30 and 45° C, and the samples content of sodium and potassium differed. In samples incubated at 45° C, the results did not differ for calcium, but iron was high in samples incubated at 30 in all concentrations, and the results did not differ much about sensory properties.

Keywords: Lemon peel, vitamin C, yogurt, Antioxidants, Minerals

INTRODUCTION

Each year, approximately 1.3 (a third of the food produced) billion tons of food is lost worldwide. (Trigo *et al*., 2020). Lemon belongs to the Rutaceae family (Kawaii *et al*., 2000). Lemon is the third most important citrus fruit after orange and tangerine. The average lemon production reached more than 4.4 million tons during the 2001/2002 season. Argentina, which produces 1.3 million tons at present, is one of the largest lemon producing countries. At the global level (FAO 2003). Lemon is a rich source of vitamin C, which acts as a water-soluble antioxidant (Rhodes, 2000).

The peel of citrus fruits is rich in flavonoid glycosides, coumarins, and volatile oils (Shahna *et al*., 2007). Several polymethoxylated flavonoids that are rarely found in plants have several important biological activities (Ahmad *et al*., 2006). Citrus fiber also contains bioactive compounds, such as polyphenols, the most important of which is vitamin C (or ascorbic acid) (Aronson, 2001).

Lemon peel is produced in industry, with high utilization potential (Goodrich, 2003; Kosseva, 2013). Lemon peel is divided into two different tissue types which are lemon peel, flavido and white (Agust, 2003). Aflavor is the outer layer of the peel and this is rich in essential oils, and its color is between green to yellow (Brat *et al*., 2001), which has been used since ancient times in the manufacture of flavors and perfumes (Vekiari *et al*., 2002).

The main component of lemon peel is albedo (a spongy and cellulosic layer placed under the flavor). Its thickness varies depending on the type and degree of maturity. Its high content of dietary fiber, when added to new meat products, yields healthy meats such as beef burgers (Aleson-Carbonell *et al*., 2003), Bologna (Ferna´ndez-Gine´s *et al*., 2004), and dry cured sausages. (Aleson-Carbonell *et al*., 2003). Also, the presence of associated bioactive compounds (flavonoids and vitamin C) with antioxidant properties in fresh lemons have health benefits.

Compounds found in citrus peels are very beneficial for the food industry and human health, including: sugars, flavonoids, carotenoids, folic acid, vitamin C, pectin, and essential oils. Phenolic compounds that act as antioxidants are also present in it (Patil *et al*., 2009; Albishi *et al*., 2013).

The use of agricultural waste can help in the continuous feeding system, which is increasing as a result of the continuous increase in the population. The use of agricultural waste is one of the most promising solutions to meet food needs. Lemon peel, non-toxic fruit offal, is eliminated into the environment when it can be used as a food ingredient.

Yogurt is one of the most consumed milk products, and it is the most used milk product to add healthy food and deliver it to the consumer. (Sahan *et al*., 2008; Loveday *et al*., 2013). The research aims to take advantage of lemon peel and make a milky product rich in vitamin C

MATERIALS AND METHODS

Material

Buffalo's milk was obtained from the Herd of Nasser Agriculture Secondary School, Damanhour City, EL-Beheira Governorate, Egypt. Yoghurt starter culture was obtained from CHR- Hansen`s laboratories, Denmark, under commercial name type (FD–DVS–YC–X11) containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii*ssp. *bulgaricus.* The lemon fruits and

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polyethylene bags were obtained from the local market in Damanhour City, Egypt. All reagents and chemicals used in this study were an analytical grade.

METHODS

Lemon peels powder preparation:

The lemon fruits were obtained from the local market (Damanhour City, Egypt), then washed with municipal tap water and peeled manually using a sterilized hand-held kitchen peeler and cut into small pieces using scissors, then dried at 40°C/48 h using a hot air oven. After drying the lemon peels were ground using a blender and sieved(40 mesh), then packaged and stored in a refrigerator at 4°C until required for use.

Yoghurt manufacture:

Buffalo's milk was heated to 95°C/5 min for pasteurization. Once cooled to 45ºC, inoculation of specific lactic strains of yoghurt (CHR HANSEN Denmark) was carried out at the rate of 3%. The lemon peels powder (LPP) was respectively incorporated into the milk samples at levels of 0, 0.1, 0.2, and 0.3%. The incubation process of the samples was done at a temperature of 30 and 42°C until reached to fermentation phase (pH 4.6). The resultant yoghurt samples were cooled and stored refrigerated at 4°C±2 for 14 days.

Analytical methods

Physicochemical analysis:

Protein, dietary fiber and pH values were estimated according to AOAC (2005) methods. Estimating the degree of pH during the incubation period was measured every half hour for all treatments using a glass electrode pH-meter, type-digital (model HANNA HI9321 microprocessor). The results were expressed as the means of three replicates.

Antioxidant activity by DPPH

The radical scavenging ability of the extracts was determined using the stable DPPH free radical (2,2-diphenyl-1-picrylhydrazyl) according to Mohamed *et al.* (2018). The methanol solution was prepared previously (0.3 mL) and was mixed with 2.7 mL of a freshly prepared DPPH solution (6×10^{-5} M in 95% methanol). The mixture was shaken vigorously and left at room temperature for 60 min in the dark until stable absorbance values were obtained. The control contained methanol in place of the sample. The change in the absorbance of the extracts was measured at 517 nm using a spectrophotometer. The percentage inhibition of the DPPH radicals was calculated *using the equation below:*

$$DPPH\ scavenging\ activity\ (\%) = [(Ac–As)/Ac] \times 100 \quad (4)$$

where

***Ac* and *As* is the absorbance of the blank (control) and samples, respectively.**

Ascorbic acid (Vitamin- C):

Vitamin C has been determined using Endophenol and AOAC, (2005)

Mineral determination:

The Na, K, Ca and Fe were determined by atomic absorption spectrophotometry. For digestion with wet ashing, 5 g yoghurt samples were used. Wet digestion of samples was performed by using mixtures of two acids, namely, HNO_3–HCl. Thirty mL of concentrated HNO_3 was used for a 5.0 g sample. Each mixture was heated on a hot plate. Gently boil unit 3-6 mL digest remains. Then, 25 mL concentrated HCl was added. Increase heat, and boil until 10-15 mL volume remains. After cooling, the residue was filtered through blue band filter paper. Then the sample was diluted to 50 mL with distilled water. The blank digestions were also carried out in the same way (AOAC, 2005).

Texture profile analysis:

Texture profile analysis (TPA) was done for yoghurt samples according to (Farrag *et al.,* 2020) using the double compression test (Multi test 1d Mecmesin, Food Technology Corporation, Slinfold, W.Sussex, UK). Experiments were carried out at room temperature by compression test that generate a plot of force (N) versus time (s). A 25 mm diameter perplex conical shaped probe was used to perform the TPA analysis of samples in five different points on the sample surface. In the 1st stage, the samples were compressed by 30% of their original depth at a speed of 2 cm/min during the pretest, compression, and relaxation of the sample. From the force-time curve, the following parameters were determined according to the definition given by the International Dairy Federation (IDF, 1991).

Viscosity measurement:

The viscosity was measured according to (Farrag *et al.,* 2020). The apparent viscosity of yoghurt was measured using a Bohlin coaxial cylinder viscometer (Bohlin Instrument Inc., Sweden) attached to a work station loaded with software V88 viscometry program. The viscometer probe, system C30, was placed in the yoghurt samples cup, and measurements of viscosity were carried out at 20°C ±2°C in the up mode at the shear rate ranging from 18 to 1238 1/s. The viscosity was expressed in (mPas).

Microbiological analysis:

Coliform bacteria were determined (most probable number) as described by APHA ,2001. While molds and yeasts were enumerated on Potato Dextrose Agar (PDA) at 25°C for 5 days according to Frank *et al* 1992.

Sensory evaluations:

Throughout cold storage at 4°C (1, 3, 7 and 14 days), the organoleptic quality of experimental yoghurt will be evaluated by a ten of experienced panelists. The organoleptic test consists in appreciating yoghurt according to five parameters: taste, color, odor, consistency, and overall acceptability, with a 10-point scale**.**

RESULTS AND DISCUSSION

Physicochemical properties of Yoghurt

Total protein, fiber, and vitamin-c content:

The protein content of yoghurts samples ranged between 3.78 and 3.84% for $C\text{-}_{42}$ and $T2\text{-}_{30}$, respectively. The finding observed that the addition of LPP and incubation temperature had no significant effect on the protein content of all yoghurt samples.

As shown in Table (1) control yoghurt samples were free from dietary fibers, but the addition of LPP had led to an increase in the content of dietary fibers in yoghurt samples for same treatment but incubated at different temperatures of 30 and 42°C had contain equal total fiber content, The content of the samples in dietary fiber increased by increasing the percentage of adding lemon peel, it was ranged from 0.045 and 0.075% for T1 and T3, respectively.

Table 1. Determination of total protein%,total fiber% and vit.C(mg/100g) in different yoghurt samples. [i]

Treatments	Component		
	Total protein %	Total fiber %	Vit. C (mg/100 g)
C-30	3.80±0.01	0.00	0.88±0.03
T1-30	3.81±0.03	0.045	0.88±0.06
T2-30	3.84±0.01	0.050	1.18±0.07
T3-30	3.83±0.05	0.075	1.47±0.11
C-42	3.78±0.01	0.00	0.38±0.01
T1-42	3.82±0.03	0.045	0.60±0.03
T2-42	3.83±0.03	0.050	0.76±0.02
T3-42	3.83±0.02	0.075	0.87±0.08

The table shows the concentration of vitamin C in yogurt and the concentration of the vitamin was higher in yogurt incubated at a temperature of 30 ° C than yogurt incubated at 45 in all treatments and also in control, and the ratio ranged in yogurt incubated at a temperature of 30 from 0.88 mg / 100g to 1.47 mg / 100g and the control was 0.88 mg / 100g, while the vitamin concentration in yogurt incubated at 45 temperature ranged from 0.60 mg / 100g to 0.87 mg / 100g and for the control it was 0.38 mg / 100g.

pH determination:

The pH was measured every half hour during the incubation.It is clear from the figure that the yogurt incubated at a temperature of 30°C took longer than that the yogurt incubated at a temperature of 45 ° C, and that the acidity decreased more in the samples added to the ground lemon peel.

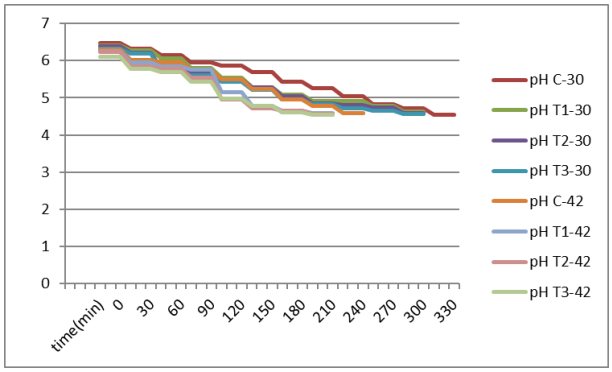

Figure 1. The pH of the samples during the manufacture of yogurt

Minerals content:

Table (2) shows concentration of elements (sodium, potassium, calcium, and iron) in the yogurt samples.The percentage of mineral elements varies between yoghurts incubated at 45 °C and 30 °C. As for the sodium component, its percentage ranged between 2000 to 2750 ppm, while it was 1750 ppm, in yogurt incubated at a temperature of 45, which is higher than yogurt incubated at a temperature of 30, which ranged between 1500 to 2250 ppm and That was in the control 1250 ppm.

As for potassium, the percentage was higher in yogurt incubated at 45 ° C in the control and the third treatment (where it was 4250 ppm and 3500ppm in the control, while in the third treatment 6750 ppm and 6250ppm), while it was equal in the first and second treatment (5250ppm and 6250ppm).

As for calcium, its percentage was higher in yogurt incubated at 45 °C in the second and third treatments than yogurt incubated at 30 ° C (in the second treatment 29500ppm and 24250ppm, while the third treatment was 29500ppm and 25000ppm), but in the first treatment, it was higher in the incubated yogurt It was 30-24 250ppm and 22500 ppm in 45 degree yogurt.

In the case of iron, its percentage was higher in yogurt incubated at a temperature of 30 and ranged between 42 to 70 ppm and in the control, it was 29 ppm, but in the case of yogurt incubated at a temperature of 45, its percentage ranged between 38 to 48 ppm and in the control, it was 22 ppm .

Table 2. Determination of minerals (Na, K, Ca and Fe ppm) in different yoghurt samples. [ii]

Minerals (ppm)	Treatments							
	30 °C				42 °C			
	C-30	T1-30	T2-30	T3-30	C-42	T1-42	T2-42	T3-42
Na	1700	24250	24250	25000	1750	2000	2500	2750
K	3500	5250	6250	6250	4250	5250	6250	6750
Ca	17000	24250	24250	25000	17750	22500	29500	29500
Fe	29	42	67	70	22	38	45	48

Antioxidant activity:

As shown in Table (3) the addition of LPP in yoghurt manufacture led to an increase the antioxidant activity in all yoghurt samples incubated at both 30 and 42°C compared to controls. At the same time, the antioxidant activity increased by increasing the LPP addition. While yoghurt samples incubated at 30 °C were high in the antioxidant activity compared to others incubated at 42°C. The antioxidant activity decreased significantly in all treatments during the prolonged refrigerated storage period of 14 days.

Table 3. antioxidant activity (%) of different yoghurt samples [iii].

Treatments	Storage period (days)			
	1	3	7	14
C-30	8.76±0.04	6.75±0.25	3.25±0.17	0.82±0.18
T1-30	10.64±0.65	8.58±0.59	5.18±0.74	2.86±0.58
T2-30	14.80±0.41	12.78±0.42	9.60±0.48	7.52±0.67
T3-30	16.07±0.98	14.17±0.88	10.92±1.04	8.68±1.07
C-42	9.48±0.25	7.37±0.29	3.93±0.26	1.54±0.31
T1-42	10.87±0.25	8.76±0.25	5.52±0.43	3.21±0.18
T2-42	12.63±0.61	10.56±0.63	7.27±0.65	4.94±0.67
T3-42	14.97±0.16	13.02±0.25	9.82±0.26	7.55±0.27

Yoghurt Rheology

One of the most important features that determine the efficiency of yogurt is its texture, and the excess is divided and classified as false plastic, and it can be a viscous and flexible liquid in the case of yogurt that is whipped or drunk. Or a solid, flexible, viscous material, if in the case of the yogurt series, it turns out to be a time-dependent thinning behavior, and it is described as a thixotropic period because the structural collapse resulting from the lobe is not completely reversible by the lobe stop glacier (Lee and Lucey, 2010). The protein network that forms in a milk product is based on a set of soft-touch features (Delikanli and Ozcan, 2017).

Hardness is regarded as the force required to attain a certain deformation and is considered a measure of the hardness of the yogurt (Mudgil *et al*., 2017). As shown in table (4), The hardness values of yogurt samples incubated at 45 °C ranged from 400 to 501.4 mN and the control was 401mN, in yogurt samples incubated at 30 °C ranged from 201.5 to 301.6 mN while the control was 200mN . That is mean, that in the case of incubation at 45°C, the hardness

was higher than that of incubation at a temperature of 30 ° C. The degree of hardness is approximated in the case of adding ground lemon peel in yoghurt incubated at a lower temperature, which is higher than that of the control.The degree of hardness is approximated in the case of adding ground lemon peel in yogurt incubated at a temperature higher with ratios of 0.1 and 0. 2 and is close to the control, while it is higher when added by a ratio of 0.3 is higher than that in the control.It was found that the hardness of yogurt increased with increasing incubation time Sah *et al.* (2015).In particular, a lower yoghurt incubation time can adversely affect the texture properties of the yoghurt.

Table 4. Texture profile analysis of different yoghurt samples.[iv]

Sample	Hardness (mN)	Springiness (mm)	Cohesiveness	Gumminess (mN)	Chewiness (mN*mm)
1	400	0.402439024	0.331088944	132.4355776	53.29724464
2	401.1	0.697160883	0.672142551	269.5963773	187.9520486
3	501.4	0.363136176	0.300321697	150.5812987	54.68151699
4	401	0.316011236	0.494953718	198.4764409	62.72078541
5	301.6	0.37660485	0.369472839	111.4330083	41.96621138
6	299	0.096153846	0.020794166	6.217455563	0.597832266
7	201.5	0.231707317	0.182975712	36.86960595	8.542957476
8	200	0.229102167	0.177039711	35.40794222	8.112036299

Table (4) shows The Springiness value of the sample indicates the recoverability of the sample against the first deformation that was activated during the interpretation period. The Springiness value of the product is very necessary to indicate the quality of the product (Yildiz et al., 2015). The Springiness rates (mm) for yogurt samples ranged from 0.363136176 to 0.697160883 while it was less than the control 0.316011236, which indicates that the value increased with the addition of dried lemon peel powder in milk incubated at 45°C. The yoghurt was incubated at 30 °C and in the Springiness it reached the top of the samples between 0.096153846 and 0.376604850 while it was less than the control 0.2291021

The cohesiveness indicates the strength of internal bonds making up the body of food and the degree to which a food can be deformed before it breaks (Chandra and Shamasundar, 2015). The maximum and minimum cohesiveness values have been determined in yogurt samples incubated at 45° C 0.300321697 to 0.672142551 while it was in the control 0.494953718 and the values of the yogurt samples incubated at 30°C were between 0.020794166 to 0.369472839 and it was 0.177039711 in the control .

Consolidation is considered as the ratio between the area of positive strength during the second breakout to that of the first breakout. It is measured as the rate at which a substance disintegrates under the mechanical influence. Cohesion refers to the ability of a product to hold together (Chandra and Shamasundar, 2015).

Gumminess is defined as the product of hardness and bonding in the yoghurt samples incubated at 45°C 132.4355776MN to 269.5963773MN while it was less than the control 198.4764409MN and the values for samples of yoghurt incubated at 30°C ranged from 6.217455563MN to 111.4330083MN and it was 35.40794222MN in the control.

The chewiness is measured in terms of the energy required to masticate a solid food and should be calculated in TPA of solid food. It is calculated as the product of hardness springiness x cohesiveness of the sample (Mehta et al., 2012) . The chewiness value of the yogurt samples incubated at 45° C ranged between 53.29724464 mN*mm to187.9520486 mN*mm while it was in the control 62.72078541 mN*mm and the values of the yogurt samples incubated at 30° C was between 0.597832266 mN*mm to 41.96621138 mN*mm and it was 8.112036299 mN*mm in the control .

Apparent viscosity of yoghurt

The viscosity of yoghurt is affected by some factors, including the density and bonding of casein micelles, in addition to their spatial structure and cleavage (Lucey and Singh 1998). Figure (2) shows the effect and results of shear ratios on the viscosity of yoghurt. As we note, in the beginning, the apparent viscosity in all samples was not greatly affect the shear rate. Then the viscosity of all samples appears drastically It decreases with increasing shear rate. Variety yogurt shows of non-Newtonian (Steffe, 1996). They demonstrate a range of different non-original actions such as yield stress, shear reduction, viscoelasticity, and time dependence [Stone and Sidle, 1993]. The apparent viscosity of all types and shapes of yogurt is greater than that of incubated at 30 °C, and yogurt is considered a multiple and different system of casein micelles with water retention [Izadi, et al., 2015]. It was found that T3 showed the highest viscosity rates in all other treatments, followed by T2, T4 and T1 treatment, and control. treatment or treatment.

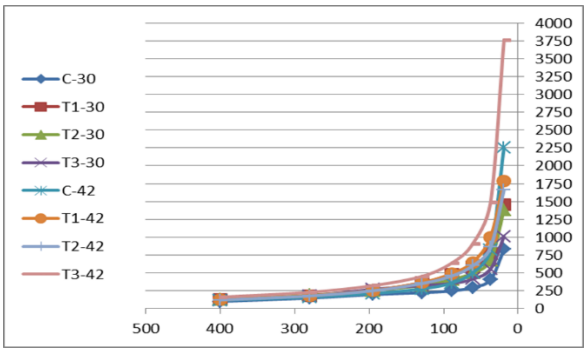

Figure 2. Apparent viscosity of yoghurt samples at different shearing rates.

As it can be seen from the table(6), the Yeast and Coliform group did not detect in the beginning, the Yeast detected after 14 days, but Coliform group was not detect.

Table 6. Yeasts and coliform group and E.coli in different yoghurt samples.

Treatments	Yeast				Coliform			
	1	7	14	21	1	7	14	21
C-30	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
T1-30	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
T2-30	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
T3-30	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
C-42	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
T1-42	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
T2-42	nd	nd	Nd	≥10	Nd	nd	Nd	Nd
T3-42	nd	nd	Nd	≥10	Nd	nd	Nd	Nd

As it can be seen from the table, the Yeast and Coliform group did not detect in the beginning, the Yeast detected after 14 days, but Coliform group was not detect.

The effect addition of lemon peel on the sensory evaluation of yoghurt during the storage period at 4°C ± 1°C for 14 days is shown in Table 7. In fresh samples, the T1

treatment had the best color, flavor, and texture. The control treatment was evaluated the best for overall acceptability followed by T1 and T2. After 3 days, T1 treatment recorded the best value for all sensory attributes compared to other treatments. After 14 days, T1 treatment got the highest score for all sensory properties compared to other treatments.. In all treatments, the storage caused a negative impact on flavor, but T1 enhanced yoghurt flavor after 3 days compared to the fresh yoghurt. For texture and overall acceptability, the fresh products in all treatments had the highest scores compared to those that were stored for 3 days or 14 days. There were no differences between the results between samples incubated at 30°C and samples incubated at 45°C.

Table 7. Sensory evaluation of different yoghurt samples during cold storage.

Storage periods (days)	Treatments							
	30 °C				42 °C			
	C-30	T1-30	T2-30	T3-30	C-42	T1-42	T2-42	T3-42
				Taste				
1	9.75±0.46	9	8.5±0.53	6.75±0.89	9.63±0.52	9	8.5±0.53	6.5±0.76
3	9	8.17±0.41	8.17±0.41	6.67±0.52	8.67±0.52	8.5±0.55	8.17±0.41	6.67±0.52
7	8	8	8	6.13±0.35	8.13±0.35	8.25±0.46	7.88±0.35	6.38±0.52
14	7±0.53	6.63±0.52	6.13±0.64	4.88±0.35	7.13±0.64	6.88±0.35	6.88±0.35	4.88±0.35
				Odor				
1	9.63±0.52	8.88±0.35	9.00	8.00±0.93	9.5±0.53	8.88±0.35	8.75±0.46	7.88±0.99
3	8.83±0.41	8.33±0.52	8	7.17±0.75	8.67±0.52	8.33±0.52	8	7±0.63
7	8	8	7.63±0.52	6.13±0.35	8.25±0.46	8	7.88±0.35	6.13±0.35
14	6.13	6.88±0.35	6.5±0.53	5.38±0.52	7.13±0.35	6.88±0.35	6.5±0.53	5±0.53
				Color				
1	9.63±0.52	8.88±0.35	8.88±0.35	8.38±0.52	9.63±0.52	9	9	7.88±0.83
3	8.33±0.41	8.17±0.41	8.17±0.41	7.17±0.75	8.83±0.41	8.33±0.52	8.33±0.52	7.17±0.41
7	8.13±0.35	8	7.88±0.35	6.63±0.52	8.13±0.35	8	7.88±0.35	6.75±0.46
14	7.38±0.52	6.75±0.46	6.5±0.53	5.25±0.46	7.25±0.46	7.13±0.35	6.63±0.52	5.25±0.46
				Texture				
1	9.75±0.46	9.13±0.35	9±0.53	7.88±0.83	9.63±0.52	9	9	8.25±0.71
3	8.67±0.52	8.33±0.52	8.33±0.52	7.33±0.52	8.67±0.52	8.17±0.41	8.17±0.41	6.67±0.52
7	8	8	7.13±0.35	6.63±0.52	8	8	7.25±0.46	6.38±0.52
14	7	6.5±0.76	6.38±0.74	4.88±0.35	7±0.53	6.88±0.35	6.25±0.71	5.25±0.71
				Overall acceptability				
1	9.88±0.35	9.38±0.52	9.38±0.52	7.13±0.64	9.88±0.35	9.50±0.53	9.13±0.35	7.13±0.64
3	8.67±0.52	8.33±0.52	8.33±0.52	7±0.63	9	8.33±0.52	8.33±0.52	7.17±0.41
7	8.25±0.71	8.13±0.35	8	6.38±0.74	8±0.93	7.13±0.38	8.13±0.35	6.63±0.74
14	6.25±0.38	6.88±0.64	6.63±0.52	4.88±0.35	7.25±0.46	7.13±0.35	6.75±0.71	4.88±0.35

REFERENCES

Agust, M. (2003). Lemon and orange albedo as a new source of dietary fiber: Application to bologna sausages. Meat Sci., 67 (1): 7–13.

Ahmad, M.M., Z. Salim-ur-Rehman, F.M. Iqbal-Anjum and J.I. Sultan, (2006), "Genetic Variability to Essential Oil Composition in Four Citrus Fruit Species", Pak. J. Bot., 38(2): 319-324.

Aleson-Carbonell L, Ferna´ndez-Lo´pez J, Sayas-Barbera´ E, Sendra E, Pe´rez-A´lvarez JA. .(2003). Utilization of lemon albedo in dry-cured sausages. *J Food Sci*, 68(5): 1826–1830.

Albishi T, John JA, Al-Khalifa AS, Shahidi F. (2013). Antioxidant, anti-inflam- matory and DNA scission inhibitory activities of phenolic compounds in selected onion and potato varieties. J Funct Foods. 5(2):930–939.

AOAC. (2005). Association of official analytical chemists-official methods analysis of the association analytical chemists, 18th ed. AOAC, Washington, DC.

AOAC., 2010. Association of Official Analytical Chemists. Official Methods of Analysis, 19th ed. Washington, D. C.,U.S.A.

APHA. (2001).Standard methods for the examination of dairy products. American Public Health Association Washington DC..

Aronson, J.K., (2001). Nature Publishing Group. Retrieved from:http://medicine.nature.com.

B. Delikanli, T. Ozcan Improving the textural properties of yogurt fortified with milk proteins Journal of Food Processing and Preservation, 41 (5) (2017), p. e13101

Brat P, Olle D, Gancel AL, Reynes M, Brillouet JM. (2001). Essential oils obtained by flash vacuum -expansion of peels from lemon, sweet orange, mandarin and grapefruit. *Fruits*, 56(6): 395–402.

Rhodes, C. J., (2000). "Toxicology of the Human Environment—The Critical Role of Free Radicals," CRC Press, London, , p. 512.

CHANDRA, M.V., SHAMASUNDAR, B.A. (2015). Texture Profile Analysis and Functional Properties of Gelatin from the Skin of Three Species of Fresh Water Fish, *International Journal of Food Properties*, 18:3, 572-584. https://doi.org/ 10.1080/ 10942912. 2013.845787

FAO. (2003). Estadstica. www.fao.org.

Farrag, A. F., Zahran, H., Al-Okaby, M. F., El-Sheikh, M. M., & Soliman, T. N. (2020). Physicochemical Properties of White Soft Cheese Supplemented With Encapsulated Olive Phenolic Compounds. *Egyptian Journal of Chemistry*, *63*(8), 8-9.

Ferna´ndez-Gine´s JM, Ferna´ndez-Lo´pez J, Sayas-Barbera´ E, Sendra E, Pe´rez-A´lvarez JA. (2004). Lemon albedo as a new source of dietary fiber: Application to bologna sausages. *Meat Sci*, 67(1): 7–13.

Frank FJ, Christen LG, Bullerman LB. (1992).Tests for groups of microorganisms. In Marshal, R.T., (Ed), Standard Methods for the Examination of Dairy Products, 16th Edn. American Public Health Association Washington DC USA.;pp:271-286.

Goodrich, R. *(*2003*).* Citrus fruits. Lemons. *In* B. Caballero P. Finglas & F. Toldra *(Eds.)*, Encyclopedia of food sciences and nutrition *(pp.* 1354–1359*). Oxford Academic Press.*

International IDF, (1991).Standards International Dairy Federation. IDF-Square Vergote 41 Brussels Sec 74A..

Izadi Z, Nasirpour A, Garoosi GA, Tamjidi F. (2015). Rheological and physical properties of yoghurt enriched with phytosterol during storage. J Food Sci Technol.;52:5341-46.

Kosseva, M. R. (2013). Sources, characterization, and composition of food industry wastes. In M. R. Kosseva & C. Webb (Eds.), Food industry wastes (pp. 37–60). Academic Press.

Kawaii, S., T. Yasuhiko, K. Eriko, O. Kazunori, Y. Masamichi, K. Meisaku, ChihiroIto and F. Hiroshi, (2000), "Quantitative study of flavonoids in leaves of *Citrus* plants", J. Agric. Food Chem., 48: 3865-3871.

Lee WJ, Lucey JA. (2010).Formation and physical properties of yoghurt. Asian-Aust J Anim Sci.;23:1127-36.

Loveday, S. M., A. Sarkar, and H. Sing. (2013). Innovative yoghurts: novel processing technologies for improving acid milk gel texture. Food Sci. Technol. 33:5–20.

Lucey JA, Singh, H. (1998). Formation and physical properties of acid milk gels: a review. Food Rev Int.;7:529-42.

MEHTA, F., RAJAGOPALAN, R., TRİVEDİ, P. (2012). Formulation, optimization and texture characterization of environment friendly gum. Der Pharmacia Sinica, 3(6):664-679.

Mohamed, F.A.E.F., Salama, H.H., El-Sayed, S.M., El-Sayed, H.S. and Zahran, H.A., 2018. Utilization of natural antimicrobial and antioxidant of Moringa oleifera leaves extract in manufacture of cream cheese. J Biol Sci, 18(2), pp.92-106.

MUDGİL, D., BARAK, S., KHATKAR, B.S. (2017). Texture profile analysis of yoghurt as influenced by partially hydrolyzed guar gum and process variables. Journal of Food Science and Technology, 54(12): 3810-3817. https://doi.org/10.1007/s13197-017-2779-1

Patil P D, Gude V G, and Deng S. (2009) "Biodiesel production from Jatropha curcas, waste cooking and Camelina sativa oils". Industrial & Engineering Chemistry Research 48: 10850-10856

Rao MA. Rheology of fluids and semisolid foods. Aspen Publishers Inc Maryland. 1999.

Sah BNP, Vasiljevic T, McKechnie S, Donkor ON. (2015). Effect of refrigerated storage on probiotic viability and the production and stability of antimutagenic and antioxidant peptides in yogurt supplemented with pineapple peel. J Dairy Sci.;98(9):5905–5916. doi: 10.3168/jds.2015-9450. [PubMed] [CrossRef] [Google Scholar]

Sahan, N., K. Yasar, and A. A. Hayaloglu. (2008). Physical, chemical and flaveur quality of non- fat yogurt as affected by a ß- glucan hydro colloidal composite during storage. Food Hydrocolloids 22:1291–1297.

Steffe, J.F. (1996) Rheological Methods in Food Process Engineering. 2nd Edition, Freeman Press, East Lansing.

Stone H, Sidel JL.(1993). Sensory evaluation practices, nd2 edn. Academic press San Diego CA..

Trigo, J. P., Alexandre, E. M. C., Saraiva, J. A., & Pintado, M. E. (2020). High value-added compounds from fruit and vegetable by-products -Characterization, bioactivities, and application in the development of novel food products. *Critical Reviews in Food Science & Nutrition*, *60*(8), 1388–1416.

Vekiari SA, Protopadakis EE, Papadopoulou P, Papanicolau D, Panou C, Vamvakias M. (2002). Composition and seasonal variation of the essential oil from leaves and peel of a cretan lemon variety. *J Agric Food Chem*, 50(1): 147–153.

Yildiz, O., Yurt, B., Toker, O. S., Ceylan, M. M., Yilmaz, M. T., & Baştürk, A. (2015). Pasting, textural and sensory characteristics of the Kofter, a fruit-based dessert: Effect of molasses and water concentration. *International Journal of Food Engineering*, 11(3), 349– 358. https://doi.org/10.1515/ijfe-2014-0313

تأثير اضافة مسحوق قشور الليمون علي خواص اللبن الزبادي

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قشور الليمون منتج ثانوي صلب يتم إنتاجه أثناء الصناعة وغالبًا ما يتم التخلص منه كنفايات زراعية. يبلغ إجمالي فقد / هدر الغذاء 1 تريليون دولار ، ويتناول الكثير من الأبحاث الحديثة كيفية الاستفادة من المخلفات الزراعية لتقليل الهدر وتحسين استخدام المخلفات الزراعية. يهدف هذا البحث إلى الاستفادة من قشور الليمون التي يتم التخلص منها ، وكذلك لرفع محتوى الزبادي من فيتامين سي الذي يعمل على رفع المناعة. من المعروف أن اللبن ومنتجاته فقيرة في محتواها من فيتامين سي. في هذا البحث أضيف قشر الليمون المطحون إلى اللبن بتركيزات مختلفة. (0.1، 0.2، 0.3٪) بهدف رفع محتوى فيتامين سي في الزبادي وتم التحضين علي درجات حرارة مختلفة 30°و 45°م وتم تقدير البروتين والألياف والكالسيوم والصوديوم والحديد والبوتاسيوم. تم تقدير مضادات الأكسدة واللزوجة و تتبع رقم الايدروجين أثناء التصنيع ، وتطلبت العينات المحتضنة عند 30 درجة وقتًا أطول أثناء الحضانة للوصول إلى الرقم الهيدروجيني المطلوب. كان محتوى فيتامين ج أعلى في العينات المحتضنة عند 30 °م ، كما كان الحال بالنسبة لمضادات الأكسدة. لم يختلف محتوى البروتين في العينات بين العينات التي أضيف إليها قشر الليمون والعينة الكنترول ، وكذلك بين العينات المحتضنة عند 30 و 45 درجة مئوية ، كما اختلف محتوى العينات من الصوديوم والبوتاسيوم. في العينات المحتضنة عند 45 ، لم تختلف النتائج بالنسبة للكالسيوم ، لكن بالنسبة للحديد كان مرتفعًا في العينات المحتضنة عند 30 في جميع التركيزات ، ولم تختلف النتائج كثيرًا فيما يتعلق بالخصائص الحسية.

الكلمات الدالة :قشر اليمون ,فيتامين ج ,الزبادي ,مضادات الاكسدة و المعادن

[i] ***(C-30) control as yoghurt incubated at 30 °C; T1-30, T2-30, T3-30 LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 30°C;(C-42) control as yoghurt incubated at 42 °C; T1-42, T2-42, T3-42 LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 42°C.**

****Small letters refers to significant differences between treatments (p<0.05) in the same scale**

[ii] ***(C_{30}) control as yoghurt incubated at 30 °C; $T1_{30}$, $T2_{30}$, $T3_{30}$ LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 30°C;(C_{42}) control as yoghurt incubated at 42 °C; $T1_{42}$, $T2_{42}$, $T3_{42}$ LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 42°C.**

****Small letters refers to significant differences between treatments (p<0.05) in the same scale**

[iii] ***(C_{30}) control as yoghurt incubated at 30 °C; $T1_{30}$, $T2_{30}$, $T3_{30}$ LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 30°C;(C_{42}) control as yoghurt incubated at 42 °C; $T1_{42}$, $T2_{42}$, $T3_{42}$ LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 42°C.**

****Small letters refers to significant differences between treatments (p<0.05) in the same scale**

[iv] ***(C_{30}) control as yoghurt incubated at 30 °C; $T1_{30}$, $T2_{30}$, $T3_{30}$ LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 30°C;(C_{42}) control as yoghurt incubated at 42 °C; $T1_{42}$, $T2_{42}$, $T3_{42}$ LPP was added at ratio of 0.1, 0.2 and 0.3 %, respectively to yoghurt incubated at 42°C.**