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PHYSICOCHEMICAL AND TEXTURAL PROPERTIES OF READY-TO-EAT YOGURT FORTIFIED WITH DRIED PURSLANE (*PORTULACA OLERACEA* L.)

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ABSTRACT

In the study use of vacuum-oven dried cultivated purslane in ready-to-eat yogurt production was observed. Yogurt samples were fortified with dried purslane in different ratios 0%, 0.5% and 1.0% for PC (control), PUR1 and PUR2, respectively and kept at 4±1°C for 21 days. Total dry matter (%) and ash (%) increased in accordance with the amount of purslane used and no pronounced change was observed in fat (%) content and pH. Titratable acidity (L.A %) and pH values ranged between 1.32-1.52 and 4.37-4.08 during storage period, respectively. Lightness (ΔL^*) and greenness (a^*) decreased and yellowness (b^*) increased in yogurt samples depending on the purslane amount. Significant color difference ($\Delta E^*>3$) was observed in fortified yogurt samples ($P<0.05$). Syneresis decreased and texture parameters slightly decreased with purslane use except cohesiveness and gel became softer. Purslane flavor, sour taste and improved texture were expressed in fortified yogurts. PUR1 was found more acceptable sensorially than other samples.

Keywords: Purslane, *Portulaca oleracea* L., yogurt, fortification, ready-to-eat.

KURUTULMUŞ SEMİZOTU (*PORTULACA OLERACEA* L.) İLE ZENGİNLEŞTİRİLMİŞ TÜKETİME HAZIR YOĞURDUN FİZİKOKİMYASAL VE TEKSTÜREL ÖZELLİKLERİ

ÖZ

Araştırmada vakumlu etüv ortamında kurutulmuş semizotunun tüketime hazır yoğurt üretiminde kullanımı araştırılmıştır. Kurutulmuş semizotu PC (kontrol), PUR1 ve PUR2 örneklerinde sırasıyla %0, %0.5 ve %1.0 oranlarında kullanılmış ve örnekler 21 gün buzdolabında depolanmıştır. Örneklerde kullanılan semizotu miktarına bağlı olarak toplam kuru madde (%) ve kül (%) değerlerinde artış gözlenirken, yağ (%) içeriği ve pH açısından belirgin bir değişim gözlenmemiştir. Depolama süresince örneklerin titrasyon asitliği değerleri (% L.A) ve pH sırasıyla 1.32-1.52 ile 4.37-4.08 arasında değişmiştir. Semizotu miktarına bağlı olarak yoğurt örneklerinde parlaklık (ΔL^*) ve yeşillik (a^*) değerleri azalmış, sarılık (b^*) değeri artmıştır. Semizotu ilaveli örneklerde kontrolle kıyaslandığında

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önemli renk farkı (ΔE^*> 3) gözlenmiştir (P <0.05). Semizotu ile zenginleştirilmiş örneklerde sinerez azalmış, iç yapışkanlık değeri dışındaki tekstür parametrelerinde bir miktar azalma ile birlikte daha yumuşak bir jel yapısı meydana gelmiştir. Semizotu aroması, ekşi tat ve iyileşmiş tekstür zenginleştirilmiş yoğurtlarda ifade edilen duyusal sonuçlardır. Panelistler tarafından PUR1 duyusal olarak daha kabul edilebilir bulunmuştur.
Anahtar kelimeler: Semizotu, *Portulaca oleracea* L., yoğurt, zenginleştirme, tüketime hazır.

INTRODUCTION

Yogurt is a popular fermented milk product beneficial for human diet (Lucey et al., 1999; Dello-Staffolo et al., 2004). In the production milk is fermented by starter cultures of *Streptococcus salivarius* subsp *thermophilus* and *Lactobacillus delbrueckii* subsp *bulgaricus* (Tamime and Robinson, 2007; Damin et al., 2009). Due to presence of these living microorganisms yogurt is accepted as a healthy food with functional properties (Tamime & Robinson, 2007; Chouchouli et al., 2013; Mani-López et al., 2014; Chen et al., 2017; Huang et al., 2020). Among the other dairy products yogurt is more functional with its composition and also its applicability to various alternative meals. Consumer's tendency to consume healthy food varieties made yogurt a good choice (Martin-Diana et al., 2003; Fagan et al., 2006; Isleten and Karagul-Yuceer, 2006; Sigdel et al., 2018). In the markets there exist yogurts with varying in fat composition (non-fat, low-fat, whole fat etc.), probiotic options, physically different alternatives as drinkable, concentrated, set and stirred types, frozen, dried yogurts and value added forms as flavored, fruity yogurts and also yogurts enriched with bioactive components (Dello-Staffolo et al., 2004; Isleten and Karagul-Yuceer, 2006; Tamime and Robinson, 2007; Loveday et al., 2013; Mani-López et al., 2014).

Purslane (*Portulaca oleracea* L.) is a native plant of India and Middle East that is cultivated in tropical and sub-tropical regions of the world (Yan et al., 2012; Zhou et al., 2015; Wainstein et al., 2016). It is known as one of the 8 most common plants grown in the world (Oliveira et. al., 2009; Yan et al., 2012; Alam, et al., 2014; Wainstein et al., 2016). Purslane is actually a wild plant but it is also cultivated intentionally. As one of the medicinal aromatic plant, purslane has many therapeutic and health promoting properties such as antiseptic, anti-inflammatory, analgesic, antibacterial, antidiabetic and antioxidant effect (Yan et al., 2012; Zhou et al., 2015; Wainstein et al., 2016). According to Chinese medicine purslane is responsible for long-life (Yan et al., 2012; Wainstein et al., 2016) and it is also regarded as "Global Panacea" by World Health Organization (WHO) (Alam et al., 2014; Zhou et al., 2015; Mastud et al., 2018) since containing many health promoting components such as minerals, vitamin C, vitamin E, carotenoids, essential amino acids, omega-3-fatty acid and phenolic compounds (Oliveira et al., 2009; Yan et al., 2012; Zhou et al., 2015; Wainstein et al., 2016). Since purslane is a common plant, it has different uses throughout the world. The plant is used raw, mostly in salads, as a vegetable dish by cooking, or by boiling in the form of tea or soup after drying in Mediterranean and tropical Asian countries (Oliveira et.al., 2009; Demirhan and Ozbek, 2010; Youssef and Mokhtar 2014; Zhou et al., 2015) and besides that the seeds of the plant are turned into flour by Americans and the locals of Australia to be used in bread and porridge (Zhou et al., 2015). In Turkey purslane is consumed in salads, as a vegetable dish an even more commonly by combining with yogurt in chopped raw form.

Drying is a process of removal of water to some extent present in the material. In that way deterioration reactions related to microbial spoilage and chemical reactions are minimized in biomaterial (Krokida et al., 2004; Orikasa et al., 2014). Drying is used for centuries in preserving quality of foods for longer periods of time than their fresh state, besides that transportation and storage costs are reduced (Doymaz, 2013). Fruits and vegetables can easily lose their freshness due to high moisture content (more than 80%) even in refrigerator. Quality of these agricultural products can be preserved successfully by drying (Sagar and Kumar, 2010; Orikasa et al., 2014; Yousef and Mokhtar, 2014; Khaled et al., 2020). Solar, hot air, spray, microwave, freeze drying and osmotic dehydration are the drying techniques used in food technology. (Khaled et al., 2020). Sun and solar drying techniques are traditional techniques applied for years in drying of fruits and vegetables with some limitations such as longer drying times, contamination and also degradation reactions in color and bioactive components. Convective or hot-air drying systems are conventionally applied ones, especially for vegetable products, with low technological complexity and low-cost advantage (Sagar and Kumar, 2010; Karaman et al., 2014; Orikasa et al., 2014; Yousef and Mokhtar, 2014; Figiel and Michalska, 2017; Li et al., 2019). But some adverse effects on physical properties such as texture and color of fruits and vegetables and also nutritional and sensorial defects depending on the intensity of the temperature are also reported (Sagar and Kumar, 2010; Orikasa et al., 2014; Yousef and Mokhtar, 2014; Figiel and Michalska, 2017; Li et al., 2019). Vacuum drying techniques are alternative ones that use lower temperatures in drying. Drying occurs at sub-atmospheric pressures that; water boils at lower temperatures and also absence of oxygen preserves dried product characteristics and heat sensitive compounds in short drying times (Sagar and Kumar, 2010; Karaman et al., 2014; Orikasa et al., 2014; Khaled et al., 2020).

In Turkish cuisine yogurt is consumed as plain directly and/or mixed with some vegetables, spices and herbs. These consumption practices are considered as habits and sometimes also the ways of increasing palatability and organoleptic properties of yogurt. Consumer recently demand nutrient dense, low energy, practical food solutions rather than unhealthy nutrient-poor snacks, desserts and cookies (Fernandez and Marette, 2017). Fruits, vegetables, fibers, spices and herbs can be added to yogurt either during consumption or during processing (Isleten and Karagul-Yuceer, 2006; Tarakci et al., 2011; Sigdel et al., 2018; Mousavi et al., 2019; Wang et al., 2019). Consumption of yogurt with purslane is a good example of yogurt use in Turkish cuisine. Purslane is as an excellent source of many bioactive components and can be stored as frozen or dried state for several years (Demirhan and Ozbek, 2010). Drying characteristics of purslane and use of different drying methods and their effects on purslane were investigated by the researchers (Demirhan and Ozbek, 2010; Karaaslan et al., 2013; Yousef and Mokhtar, 2014). To the best of our knowledge there are limited studies related to combination of purslane with yogurt. In these studies, researchers focused on different applications such as: use of different herbs in concentrated yogurt in fresh state (Tarakci et al., 2011), use of purslane juice in yogurt (Wu et al., 2011) and a clinical trial in which the effect of inclusion of purslane seed into yogurt during consumption is examined (Zakizadeh et al., 2015). In the present study use of vacuum-oven drying technique in dried purslane production, use of dried purslane in ready-to-eat yogurt production and the changes in quality attributes of yogurt were investigated.

MATERIAL AND METHODS

Material

Cow's milk, skim milk powder (Izi sut, Konya, Turkey) and DVS - lyophilized yogurt starter culture (CH-1, Chr. Hansen, Hørsholm**,** Denmark) used in yogurt production were supplied by Dairy Plant of Ankara University Faculty of Agriculture, Ankara, Turkey. Chemical attributes of raw cow's milk used in the study were given in Table 1. Fresh purslane was purchased from local markets (Ankara, Turkey) at once and stored approximately at 4°C for a possibly short period until drying.

Table 1. General characteristics of raw milk ($\bar{X} \pm S_x$) (n=2)

Component	Raw milk
Total solid (%)	11.69 ± 0.021
Fat (%)	3.35 ± 0.070
Ash (%)	0.70 ± 0.021
pH	6.77 ± 0.134
Titratable acidity (°SH)	6.88 ± 0.339

Methods

Drying of Purslane

Freshly obtained purslane were subjected to some stages until drying process. The plants were initially separated from foreign materials, rinsed with tap water and made ready for use. The excess water is drained as good as possible to prevent rapid deterioration of purslane. After that the leaves and the stems of purslane were separated from the whole plant and dried separately. Drying process was carried out in vacuum oven chamber (BINDER VD 53, Tuttlingen, Germany) under 20 kPa vacuum and at 60°C until final moisture content reached about 5%. Drying process was traced by measuring the moisture content gradually (OHAUS MB 45; Parsippany, NJ, USA). The dried leaves and stems were ground into fine powder before use.

Yogurt processing

Raw cow's milk was initially heated to 46-47°C for separation and standardization of fat to 1.5% and fortified with skim milk powder to 14% dry matter. The experimental design of the study was established according to the preliminary studies done by our team members (Sert and Evkaya, 2017) and the treatments of the study were given in Table 2 as PC (control), PUR1 and PUR2. In the production, the bulk milk was divided into 3 equal parts and inclusion of dried purslane was done at 55-60°C. All mixes were homogenized by Ultra-Turrax blender (IKA RW 20, Staufen, Germany) for complete dispersion of dried purslane for 5 minutes. Mixes were heated at 90°C for 10 minutes and cooled to 45°C for inoculation of yogurt culture consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. b*ulgaricus* (CH-1, Chr. Hansen, Hørsholm, Denmark). The inoculation level for each 3L of batch was 0.4 g. Following the inoculation, the bulk mixtures were poured into sterile containers of nearly 100 mL for set-type yogurt production. The incubation was carried out at 43°C until achieving pH of 4.60 - 4.70. Following the fermentation samples were cooled and kept at 4±1°C and analyzed in their chemical, physical and sensorial attributes during storage period (1, 7, 14 and 21 days). The study was performed in duplicate.

Table 2. Experimental design of the study

	Purslane plant part and ratio (%)	
Sample code	Purslane leaves	Purslane stems
PC (control)	None	None
PUR1	0.25	0.25
PUR2	0.50	0.50

Composition and physicochemical properties of yogurt samples

Yogurt samples were analyzed in their total dry matter (%), fat (%), ash (%) content with methods (AOAC, 1997), Gerber method (Renner, 1993) and Bradley et al. (1993), respectively on the 1st and 21st days of storage.

pH and Titratable acidity

The pH value was measured by immersing electrode of pH-meter (Mettler Toledo Seven2Go S2; Schwerzenbach, Switzerland). Titratable acidity of the yogurts was determined by titrating with 0.1N NaOH coupled with phenolphthalein as indicator and expressed as lactic acid (%) (Bradley et al., 1993).

Color analysis

The CIELAB parameters of yogurt samples were measured by Chroma meter (Konica Minolta CR 410, Sensing Inc., Osaka, Japan) during storage period. After calibrating the instrument by standard white plate, color parameters L^*, a^* and b^* were measured. Among these parameters L^* indicates the lightness of a material changing from 0-100 (black - white). The parameters a^* and b^* can have (+) or (-) values and denote redness (+) or greenness (-) and yellowness (+) or blueness (-) of a material, respectively. By using the measured color parameters L^*, a^* and b^*, color indices such as total color difference (ΔE), Chroma (C^*) and Hue angle (h^*) were calculated by the given equations (Pathare et al., 2013).

$$\Delta E = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2} \quad \text{Eqn (1)}$$

$$C^* = \sqrt{(a^*)^2 + (b^*)^2} \quad \text{Eqn (2)}$$

$$h^* = \tan^{-1}(\frac{b^*}{a^*}) \quad \text{Eqn (3)}$$

Syneresis

Syneresis was evaluated according to Robitaille et al. (2009) by a centrifugation (Sigma 3–18K, Osterode am Harz, Germany) of 25 g of yogurt at 2200 rpm for 10 min at 4°C. Serum (supernatant) separated after centrifugation was weighed and calculated as syneresis (%) by Equation 4.

$$Syneresis\ (\%) = (weight\ of\ supernatant \div weight\ of\ yogurt) \times 100 \quad \text{Eqn (4)}$$

Texture analysis

Textural properties of yogurt samples were determined by texture analyzer (TA. XT Plus, Stable Micro Systems, Surrey, UK). Yogurt samples were analyzed by back extrusion method in their original containers with 35-mm back extrusion cone and a 5- kg load cell. Test speed of the probe and probe penetration distance were adjusted to the values 1,5 mm/s and 20 mm, respectively. Firmness, consistency, cohesiveness and index of viscosity were the textural parameters measured in the 1st, 7th, 14th and 21st days of storage. Samples were kept in the refrigerator just 5 minutes before the analysis. For each yogurt sample measurements were done for 4 times at a time in four different cups.

Sensory analysis

Sensory evaluation of yogurt samples was carried out by 7 panelists experienced in dairy products in the Dairy Technology Department (Ankara University Agriculture Faculty, Ankara, Turkey). Sample yogurts were coded with 3-digit numbers and served to the panelists in their original containers together with water. Aroma/flavor, odor, appearance, texture and general acceptability attributes of yogurt samples were evaluated by grading test method for overall quality assessment in terms of given attributes. The grading scale used in sensory evaluation and verbal explanations of the grades were given in Table 3 (Altug-Onogur and Elmaci, 2015).

Table 3. Grading scale used in sensory evaluation of yogurt samples

Grading Scale	Score
Extremely good	10
Perfect	9
Very good	8
Good	7
Quite good	6
Fair	5
Slight fair	4
Moderate	3
Very poor	2
Extremely poor	1
Unconsumable	0

Statistical analysis

Statistical evaluation of the results was done by Minitab statistical package (version 16.0, Minitab Inc.; State College, PA, USA). In order to evaluate the effect of using different concentrations of purslane in yogurt characteristics Tukey's multiple-comparison test was applied. The level of significance of differences between treatments was determined at $P < 0.05$.

RESULTS AND DISCUSSION

Yogurt composition

The compositional properties of yogurt samples were given in Table 4. Incorporation of dried purslane significantly affected total dry matter (%) and ash (%) content of the samples ($P < 0.05$) Higher values were observed in these properties in yogurt samples with purslane (PUR1 and PUR2) than control (PC), in accordance with the level of purslane used in production. Storage period had no significant effect on these parameters ($P > 0.05$). In terms of fat (%) content neither use of purslane nor storage period had no significant effect depending on using standardized raw milk in production ($P > 0.05$).

pH and Titratable Acidity

The addition of dried purslane did not cause a significant effect in pH of sample yogurts ($P > 0.05$). Although being non-significant yogurt samples with dried purslane (PUR1 and PUR2) had higher pH values than control (PC). Similar results were stated by Hashim et al. (2009), but contrarily Espirito – Santo et al. (2013) and Sigdel et al. (2018) reported decrease in pH with presence of fruits in the system than control yogurts. However, pH decreased during storage period in yogurt samples (Table 5). This decrease and difference were significantly different in the 1st day than the remaining storage period ($P < 0.05$). The tendency of pH decreases and increase in titratable acidity in yogurt during storage is known as post-acidification reaction of lactic acid bacteria responsible for yogurt fermentation in that the acidity of yogurt samples continued to increase (Espirito – Santo et al., 2013; Mani-López et al., 2014; Rudra et al., 2017).

Table 4. Basic chemical composition of yogurt samples

Treatment [1]	Dry matter (%)	Fat (%)	Ash (%)
PC (control)	14.16 ± 0.27^{B}	1.37 ± 0.06	1.11 ± 0.01^{B}
PUR1	14.64 ± 0.12^{AB}	1.41 ± 0.03	1.27 ± 0.04^{A}
PUR2	15.40 ± 0.13^{A}	1.45 ± 0.04	1.35 ± 0.01^{A}

Values given in the table are the means ± SE of 1st day and 21th day of the storage in duplicate; values in the same column with different letters in superscript differ significantly (P <0.05).
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Table 5. pH and Titratable acidity (L.A%) values of yogurt samples in the storage days

Storage time (Day)	pH	Titratable acidity (LA %)
1	4.37 ± 0.04^{A}	1.32 ± 0.03^{B}
7	4.16 ± 0.02^{B}	1.50 ± 0.04^{A}
14	4.14 ± 0.06^{B}	1.49 ± 0.02^{A}
21	4.08 ± 0.03^{B}	1.52 ± 0.03^{A}

Values given in the table are the means ± SE on the days of storage in duplicate; values in the same column with different letters in superscript differ significantly (P <0.05).
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Titratable acidity values of the yogurt samples were significantly affected individually by purslane addition and storage period (P <0.05). Similar to pH, acidity increased that titratable acidity gradually increased during storage and significant difference was observed in the 1st day when compared with days 7, 14 and 21 (P <0.05). Besides that, PUR2 had higher titratable acidity values than PC and PUR1 during storage period (Figure 1). Addition of fruits caused a rising trend in titratable acidity of yogurts due to low pH of fruits naturally (Sigdel et al., 2018). In sample yogurt PUR2 the progress of acidity was slightly more than others this might be the reason of acidic nature of purslane and use of higher amounts when compared with PUR1.

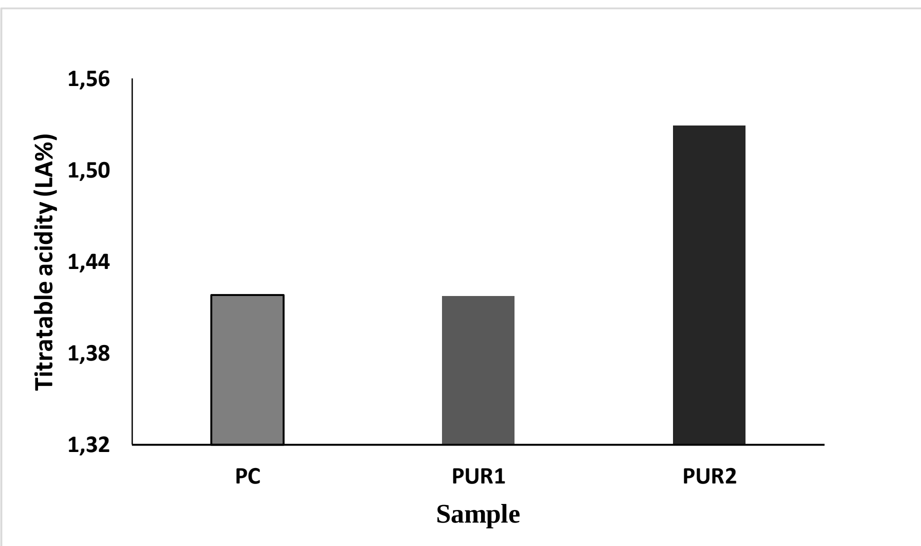

Figure 1. Titratable acidity values (L.A %) of yogurt samples during storage period in duplicate
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Color characteristics

Color is the first parameter determining consumer preference of a food product. Food products are evaluated in terms of color by measuring *L**, *a**, *b** parameters. The color indices of total color difference (*⊿E**), Chroma (*C**) and Hue angle (*h**) are calculated by measured color parameters. CIELAB color characteristics of yogurt samples were presented in Table 6. Incorporation of purslane created significant difference in all color characteristics of yogurt samples (P <0.05) except *b** for PC and PUR2. In terms of storage period *L*, a*, ⊿E, b** values were significantly different in the 1st day and Chroma (*C**) was significantly different in the 1st and 7th day of storage than the other days (P <0.05) (data not shown). Storage period did not cause a significant difference statistically in *h** values of the samples (P >0.05).

Table 6. Color characteristics of yogurt samples

Treatment[1]	*L**	*a**	*b**	*⊿E**	Chroma (*C**)	Hue angle (*h**)
PC	70.78 ± 0.04^{A}	-2.39 ± 0.01^{A}	8.66 ± 0.10^{A}	-	8.99 ± 0.07^{A}	-74.54 ± 0.13^{A}
PUR1	60.54 ± 0.23^{B}	-2.08 ± 0.07^{B}	8.11 ± 0.14^{B}	10.27 ± 0.26^{A}	8.31 ± 0.11^{B}	-75.53 ± 0.33^{B}
PUR2	56.06 ± 0.13^{C}	-1.92 ± 0.06^{C}	8.48 ± 0.12^{A}	14.74 ± 0.16^{B}	8.70 ± 0.07^{C}	-77.29 ± 0.29^{C}

Values given in the table are the means ± SE during storage period in duplicate; values in the same column with different letters in superscript differ significantly (P <0.05).

*L** value indicates whiteness of the material in light-dark axis (ranging between 100-0 values) (Maskan, 2001). Casein micelles, milk fat globules were effective in whiteness of fluid milk, take place in scattering the light in visible spectrum and fermentation causes decrease in translucency of milk (García-Pérez et al., 2005). PC yogurt was whiter than PUR1 and PUR2 with higher *L** values. As concentration of purslane increased in yogurt sample yogurt became darker. The darkening effect of purslane might be due to absorption of water by fiber present in purslane. Similar results were reported by the researchers as free water present in food surface causes higher *L** values (whiter product) (García-Pérez et al., 2005). Negative *a** values and positive *b** values in color scale of CIE system means greenish and yellowish colors perceived by human eye. Parameter *a**, followed an increasing trend (less greenish color) in increasing purslane concentration but although no regular increase was observed in all samples (PC, PUR1 and PUR2), *b** for PUR2 was higher so more yellowish than PUR1 (Table7). Similarly, in orange fiber enriched yogurts *L** values decreased and *a** and *b** values increased (García-Pérez et al., 2005). Tarakci et al. (2011), stated at 8.0% inclusion levels, purslane use in labneh (concentrated yogurt) caused decrease in *L** (87.55±1.24) and increase in *a** (-5.04 ±0.30, greenness) and decrease in *b** (10.37±1.89, yellowness) when compared with control in the 1st day of storage. Herbs used in labneh affected color characteristics differently. Vital et al. (2015), declared decrease in whiteness in supplemented yogurt but as stated by Tarakci et al. (2011), *a** and *b** changed according to color of additive used.

⊿E is an index, indicating the color difference of a material from control. Its magnitude determines the degree of difference (*⊿E*>3*;* very distinct*,* 1.5<*⊿E*<3; distinct and when *⊿E*>1.5*;* small difference exists) (Pathare et al., 2013). According to Table 6, when PC was considered as control, *⊿E* values for PUR1 and PUR2 were higher than 3; so, all purslane fortified yogurt samples were very distinctly different than PC (P <0.05).

Chroma (*C**) is the measure of colorfulness (saturation index) and measured by comparing the degree of hue with grey color under same lightness (Eqn 2). Higher chroma values are perceived by human eye more intensively (Pathare et al., 2013). Sanz et al. (2008), stated that fiber use increased *C** values in yogurt samples and yogurt became more colorful with fiber addition. However, in our samples purslane addition did not cause similar effect both in *C** and *h**, *a** regular increasing trend with increasing purslane concentration was not observed. Highest chroma values were obtained for PC with significant difference (P <0.05) (Table 6).

Hue angle (h^*) is used to indicate the difference of a color with a reference of grey color under same lightness. Usually used to define color parameters in fruits, green vegetables and meats. Higher hue angle means lesser yellow character (Angles: 0°: red hue, 360°: red hue, 90°: yellow hue, 180°: green hue and 270°: blue hue) (Pathare et al., 2013). In the samples since h^* depends on a^* and b^* (Eqn 3), with a^* (-) and b^* (+) values, h^* lies between 90°- 180° that is in between yellow-green hue and higher purslane concentrations resulted in greater hue angle measurements.

Syneresis

Syneresis is the expulsion of whey from yogurt gel network regarded as an undesirable physical defect (Lee and Lucey, 2010; Mani-López et al., 2014). This is an either spontaneous or mechanical disruption of the gel that determines the quality and stability of yogurt (Mani-López et al., 2014). In low fat yogurts syneresis and texture defects could possibly occur and in general also increase in total solid content reduce syneresis (Vital et al., 2015). But this reaction depends on the nature of the additive used; syneresis in yogurt can either increase or decrease (Lee and Lucey, 2010; Mani-López et al., 2014; Rudra et al., 2017). In the samples syneresis was not significantly affected by incorporation of purslane and storage period ($P > 0.05$). Increasing the concentration of purslane caused decrease in syneresis (Figure 2). Aberoumand (2009), reported crude fiber content of purslane leaves and stems as 8%. PUR1 and PUR2 are both enriched with purslane fiber exist in leaves and stems (Table 2). Lower syneresis was observed for PUR2 having higher fiber content than PUR1 and PC. Similarly, (Hashim et al., 2009) stated higher fiber content causes a decrease in syneresis. Use of dried fruits controls syneresis in yogurts by absorbing free water (Sigdel et al., 2018). At 0.6% and 0.8% orange fiber levels, an increase was observed in syneresis but whey released from the gel was absorbed by the fiber at 1.0% orange fiber concentrations (García-Pérez et al., 2005). A darkening effect (decrease in L^*) also observed in the samples due to absorption of water by increased purslane amounts. Syneresis in yogurt increases with storage time is a known phenomenon and use of pectin in yogurt prevents separation of the whey by interacting with casein through calcium ions (Ramirez-Santiago et al., 2010). Increase in acidity is also responsible for increase of syneresis in yogurts. Although acidity increased from day 1 to day 21, syneresis tended to decrease in our samples. Water holding capacity of yogurt gel was enhanced during storage period and this time in fiber - enriched yogurt.

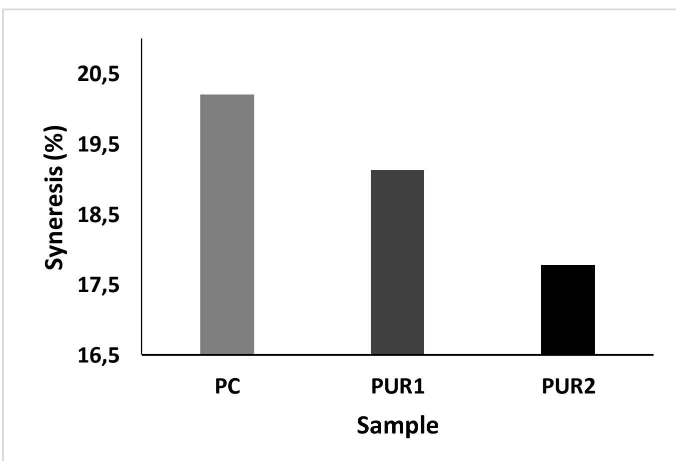

Figure 2. Syneresis (%) values of yogurt samples during storage period in duplicate
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Texture characteristics

Yogurt quality is assessed by its textural characteristics and results were presented in Table 7. Incorporation of purslane and storage period did not create significant effect on firmness (N), consistency (N.s), cohesiveness (N), index of viscosity (N.s) parameters of yogurt (P >0.05). The addition of dried purslane in amounts (PUR1 and PUR2 were 0.5% and 1.0%, respectively) resulted in decrease in firmness, consistency and index of viscosity and a slight increase in cohesiveness values when compared with PC. These results indicated that, the concentrations of purslane used in yogurt samples were not at a level that make a difference in texture. The concentration of dietary fiber used in yogurt was effective on texture characteristics. Use of 1.5% dietary fiber was ineffective on yogurt texture and at 3.0% dietary fiber dosages, significant difference was observed in texture (Hashim et al., 2009).

Table 7. Texture characteristics of yogurt samples

Treatment	Firmness (N)	Consistency (N.s)	Cohesiveness (N)	Index of viscosity (N.s)
PC (Control)	2.86 ± 0.15	30.71 ± 1.36	0.97 ± 0.01	1.79 ± 0.05
PUR1	2.76 ± 0.07	28.82 ± 0.80	0.98 ± 0.01	1.77 ± 0.09
PUR2	2.78 ± 0.17	27.24 ± 1.59	0.98 ± 0.02	1.76 ± 0.07

Values given in the table are the means ± SE during storage period in duplicate;
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Firmness is the first determining quality parameter of yogurt in sensory evaluation. Water holding capacity of milk proteins increase during storage leads to increase in firmness (Seckin and Baladura, 2012). Cold storage also strengthens textural characteristics of set-type yogurts (Wang et al., 2019). Yogurt texture changes with presence of fiber and its dose is the determinative (Seckin and Baladura, 2012; Wang et al., 2019). Firmness values of both yogurt samples increased during storage but highest values were observed in control yogurt (PC) due to rearrangement of proteins (Figure 3). Firmness values of PUR1 and PUR2 increased compatible with higher fiber dose similar to results of researchers (Seckin and Baladura, 2012; Wang et al., 2019). Similar to our results lower firmness results were determined in supplemented yogurts than control. This situation was explained as the reason of higher water in gel structure causes lower firmness values and softer gel structure in *Pleurotus ostreatus* aqueous extract (POE) supplemented yogurts (Vital et al., 2015). As stated by Vital et al. (2015), this is also associated with lower syneresis at higher fiber doses (Figure 2).

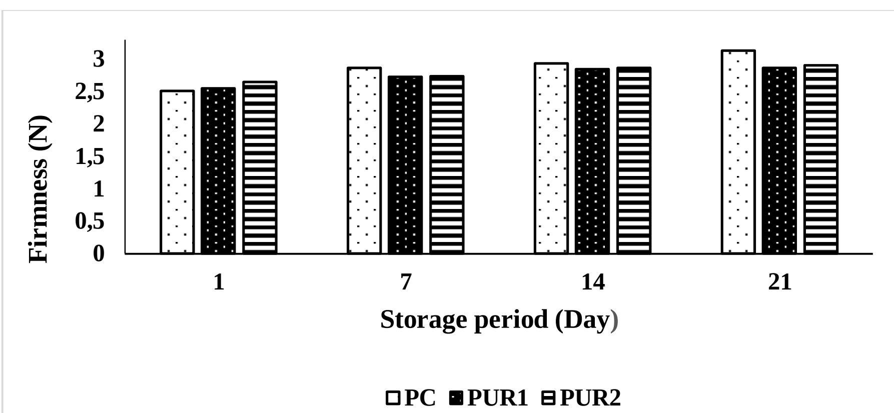

Figure 3. Firmness (N) of yogurt samples in storage days in duplicate
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Yogurt milk protein content and use of some ingredients affect curd structure and stability (Guven et al., 2005). As stated by Vital et al. (2015), the optimal dose that effects water binding and viscosity formation capability of soluble components and presence of insoluble ones in protein gel structure determines consistency. In their study neither control nor the sample with highest apple pomace (1.0%) dose got the highest consistency values. Sample with (0.5%) apple pomace got the highest and regarded as the optimal dose for water retention and viscosity building (Vital et al., 2015). In our samples, highest consistency values were observed in PC and lower in PUR1 and PUR2 with decreasing order, respectively (Table 7). Similar to firmness consistency increased during storage period due to rearrangement of proteins ($P > 0.05$).

Cohesiveness is the force required for removal of yogurt stuck on the spoon or mouth during consumption (Wang et al., 2019). Purslane addition (PUR1 and PUR2) caused slight increase in cohesiveness values than PC. Although a slight difference was found, it can be concluded that incorporation of purslane made yogurt more cohesive than plain yogurt.

Despite no distinct difference was observed between the samples; PC got higher values than others in terms of index of viscosity. Inclusion of dried purslane to the yogurt resulted in less viscous structure in increasing doses (Table 7).

Sensory evaluation

Statistically aroma/flavor, texture and general acceptability characteristics were significantly affected by use of dried purslane in yogurts ($P < 0.05$) and presented in Figure 4. On the contrary, odor and appearance were not affected significantly ($P > 0.05$) but PUR1 got the highest scores in terms of odor and appearance during storage period (data not shown). Storage time did not create a significant difference in the sensory parameters ($P > 0.05$).

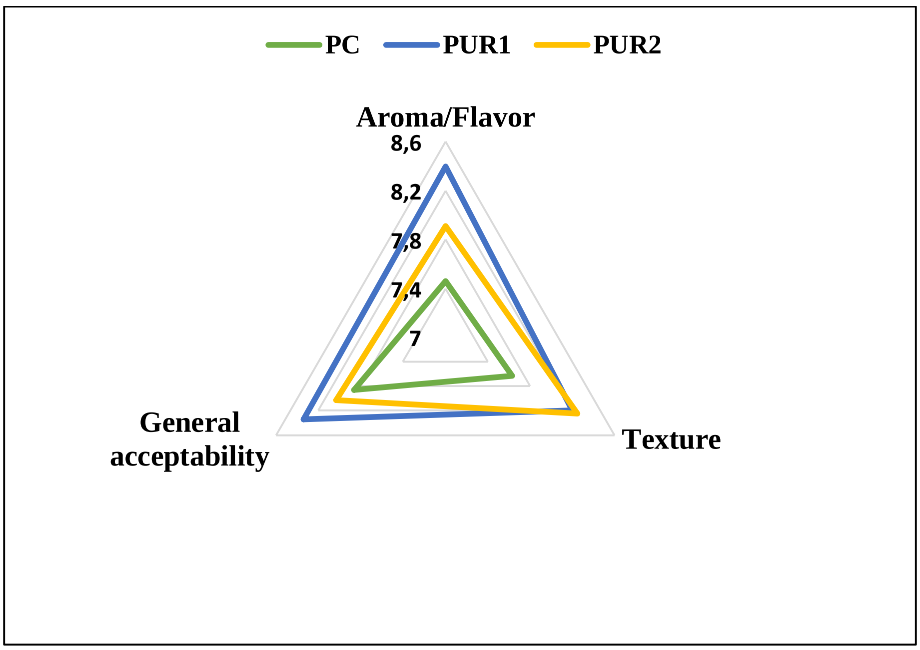

Figure 4. Sensory scores of yogurt samples during storage period ($P < 0.05$)
Treatment codes represent; PC, Yogurt (control); PUR1=Yogurt with 0.5% purslane; PUR2=Yogurt with 1.0% purslane.

Aroma/flavor and texture characteristics were mostly affected sensory parameters related to dried purslane use. The most obvious consequences of the addition of dried purslane were declared by the panelists as the formation of a purslane flavor, sour taste and improved texture in the samples compared with control. The sourness defined was more distinct in PUR2 than PUR1 due to purslane amount used and increased with storage time. So, it can be concluded that this sour sensation was related to purslane nature itself and not created a negative effect in pH of yogurt samples. All samples were ranked with scores higher than grade 7 (Table 3) so regarded as "good" at least in terms of aroma, texture and general acceptability properties. PUR1, got higher scores in terms of all sensory attributes (Figure 4) than PC and PUR2 except texture. Although, scores were very close, texture of PUR2 was ranked with higher scores than PUR1. A firmer gel structure was noted by panelists with increasing purslane amount. However, PC was found firmer than PUR1 and PUR2 according to instrumental texture results (Table 7). General acceptability of the samples followed a decreasing order as PUR1, PUR2 and PC (control) during storage period (P <0.05). Similarly, highest overall acceptability was detected in purslane added labneh samples among various alternative herbs (Tarakci et al., 2011).

CONCLUSION

In this study the use of purslane in dried state during yogurt processing was investigated and general composition, physicochemical, textural and sensory characteristics of yogurt samples were analyzed. Incorporation of dried purslane during processing did not cause a definite negative effect on properties of yogurt samples. Fat (%) content was not affected by purslane use but total dry matter (%) and ash (%) content increased in the samples in accordance with the purslane amount. According to color characteristics, purslane addition resulted in decrease in lightness (ΔL^*) and greenness (a^*) and increase in yellowness (b^*) of yogurt samples depending on the purslane dose. Yogurt samples became very different than control in terms of color (ΔE^*) with purslane addition. Syneresis decreased with use of purslane and with its increasing amounts compared to control. Although instrumental texture parameters decreased slightly with purslane use and its increasing amounts except cohesiveness, this change in texture was not declared by the panelists during sensorial evaluation. Purslane use at a ratio of (0.5%) was found more successful according to sensorial and overall evaluation. According to the results the addition of purslane in dried form suited well with yogurt and its use during yogurt processing was found acceptable and time-saving rather than preparing "yogurt with purslane" with fresh purslane at the time of consumption. Use of purslane in dried state was found promising for developing a new fermented dairy alternative for consumers requiring ready-to-eat, rapid, healthy food solutions. Besides that the results of the study presented the opportunity of using purslane in a value-added form for industrial applications. It is thought to be beneficial to investigate the effects of drying and technological applications used in yogurt processing on health promoting components of purslane.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

The research was designed by all authors and experimental stages of the research were carried out by the authors EAA and DS. Writing and editing processes were performed by the authors EAA and AG. All authors read the final version of the paper. The authors also would like to thank to Musa Evkaya for his logistic support in the study.

REFERENCES

Aberoumand, A. (2009). Nutritional evaluation of edible *Portulaca oleracea* as plant food. *Food Anal. Methods*, 2: 204–207, doi: 10.1007/s12161-008-9049-9.

Alam, A., Juraimi, A.S., Yusop, M.R., Hamid, A.A., Hakim, A. (2014). Morpho-physiological and mineral nutrient characterization of 45 collected Purslane (*Portulaca oleracea* L.) accessions

Bragantia, *Campinas*, 73:4, 426-437, doi: 10.1590/1678-4499.253.

Altug-Onogur, T., Elmaci, Y. (2015). *Sensory evaluation of foods* (In Turkish). Sidas Medya Ltd. Sti., Izmir, Turkey.

AOAC (1997). Official Methods of Analysis. 15th ed. *AOAC International,* Washington, DC.

Bradley RL, Arnold E, Barbano DM, Semerad RG, Smith DE, Vines BK. (1993). *Chemical and physical methods. Standard Methods for the Examination of Dairy Products.* Marshall, R.T. (ed.), *Am Pub Health Assoc*, Washington, DC, pages 433–531.

Chen, C., Zhao, S., Hao, G., Yu, H., Tian, H., Zhao, G. (2017). Role of lactic acid bacteria on the yogurt flavour: A review. *Int J Food Prop,* 20(1): 316-330, doi: 10.1080/10942912.2017.1295988.

Chouchouli, V., Kalogeropoulos, N., Konteles, S.J., Karvela, E., Makris, D.P., Karathanos, V.T. (2013). Fortification of yoghurts with grape (Vitis vinifera) seed extracts. *LWT - Food Sci Technol,* 53: 522-529, doi: 10.1016/j.lwt.2013.03.008.

Damin, M. R., Alcantara, M.R., Nunes, A. P., Oliveira, M. N. (2009). Effects of milk supplementation with skim milk powder, whey protein concentrate and sodium caseinate on acidification kinetics, rheological properties and structure of nonfat stirred yoghurt. *Food Sci. Technol. (Campinas.)*, 42: 1744–1750, https://doi.org/10.1016/j.lwt.2009.03.019.

Dello-Staffolo, M., Bertola, N., Martino, M., Bevilacqua, A. (2004). Influence of dietary fiber addition on sensory and rheological properties of yogurt. *Int Dairy J*, 14: 263–268, doi: 10.1016/j.idairyj.2003.08.004.

Demirhan, E., Ozbek, B. (2010). Drying kinetics and effective moisture diffusivity of purslane undergoing microwave heat treatment. *Korean J. Chem. Eng.*, 27(5): 1377-1383, doi: 10.1007/s11814-010-0251-2.

Doymaz, I. (2013). Hot-air drying of purslane *(Portulaca oleracea L.*). *Heat Mass Trans*, 49: 835–841, doi: 10.1007/s00231-013-1128-9.

Espírito-Santo, A.P., Lagazzo, A., Sousa, A.L.O.P, Perego, P., Converti, A., Oliveira, M.N. (2013). Rheology, spontaneous whey separation, microstructure and sensorial characteristics of probiotic yoghurts enriched with passion fruit fiber. *Food Res Int*, 50: 224–231, doi: 10.1016/ j.foodres.2012.09.012.

Fagan, C.C., O Donnell, C.P., Cullen, P.J., Brennan, C.S. (2006). The effect of dietary fibre inclusion on milk coagulation kinetics. *J Food Eng*, 77: 261–268, doi: 10.1016/j.jfoodeng. 2005.06.030.

Fernandez, M.A., Marette, A. (2017). Potential health benefits of combining yogurt and fruits based on their probiotic and prebiotic properties. *Adv Nutr Int Rev J.*, 8: 155-164, doi: 10.3945/an.115.011114.

Figiel, A., Michalska, A. (2017). Overall quality of fruits and vegetables products affected by the drying processes with the assistance of vacuum-microwaves. *Int. J. Mol. Sci.* 18; 71, doi: 10.3390/ijms18010071.

García-Pérez, F. J., Lario, Y., Fernández-López, J., Sayas, E., Pérez-Alvarez, J.A., Sendra, E. (2005). Effect of orange fiber addition on yogurt color during fermentation and cold storage. *Color Res. Appl.* 30: 457–463, https://doi.org/10.1002/col.20158.

Guven, M., Yasar, K., Karaca, O.B., Hayaloglu, A.A. (2005). The effect of inulin as a fat replacer on the quality of set-type low-fat yogurt manufacture, *Int J Dairy Technol,* 58 (3): 180-184, https://doi.org/10.1111/j.1471-0307.2005.00210.x.

Hashim, I.B., Khalil, A.H., Afifi, H.S. (2009). Quality characteristics and consumer acceptance of yogurt fortified with date fiber. *J. Dairy Sci*. 92: 5403–5407, doi: 10.3168/jds.2009-2234.

Isleten, M., Karagul-Yuceer, Y. (2006). Effects of dried dairy ingredients on physical and sensory properties of nonfat yogurt. *J. Dairy Sci*. 89: 2865–2872, https://doi.org/10.3168/jds.S0022-0302 (06)72559-0.

Karaaslan, S., Erdem, T., Oztekin, S. (2013). Mathematical modelling and color characteristics of purslane (*Portulaca Oleraceae* L.) leaves using different drying methods. *The Philipp Agric Scientist*, 96 (3): 171-178.

Karaman, S., Toker, O.S., Çam, M., Hayta, M., Dogan, M., Kayacier, A. (2014). Bioactive and Physicochemical Properties of Persimmon as Affected by Drying Methods. *Drying Technol*, 32: 258–267, doi: 10.1080/07373937.2013.821480.

Khaled, A.Y., Kabutey, A., Mizera, C., Hrabe, P., Herák, D. (2020). Modelling of hot-air and vacuum drying of persimmon fruit (Diospyros kaki) using computational intelligence methods. *Agronomy Res,* 18: S2, 1323–1335, doi: 10.15159/AR.20.095.

Krokida, M.K., Karathanos, V.T., Maroulis, Z.B., Marinos-Kouris, D. (2004). Drying kinetics of some vegetables. *J Food Eng,* 59: 391–403, doi: 10.1016/S0260-8774(02)00498-3.

Lee, W. J., Lucey, J.A. (2010). Formation and physical properties of yogurt. Asian-australas. *J. Anim. Sci.* 23:1127–1136.

Li, K., Zhanga, M., Mujumdar, A.S., Chitrakar, B. (2019). Recent developments in physical field-based drying techniques for fruits and vegetables. *Drying Technol,* Vol. 37, No. 15, 1954–1973, doi: 10.1080/07373937.2018.1546733.

Loveday, S. M., Sarkar, A., Singh, H. (2013). Innovative yoghurts: Novel processing technologies for improving acid milk gel texture. *Trends Food Sci Technol*, 33(1): 5–20, https://doi.org/10.1016/j.tifs.2013.06.007.

Lucey, J.A., Munro, P.A., Singh, H. (1999). Effects of heat treatment and whey protein addition on the rheological properties and structure of acid skim milk gels. *Int Dairy J,* 9: 275-279, https://doi.org/10.1016/S0958-6946(99)00074-6.

Mani-López, E., Palou, E., López-Malo, A. (2014). Probiotic viability and storage stability of yogurts and fermented milks prepared with several mixtures of lactic acid bacteria, *J Dairy Sci*, 97: 5, 2578–2590, https://doi.org/10.3168/jds.2013-7551.

Maskan, M. (2001). Kinetics of colour change of kiwifruits during hot air and microwave drying. *J Food Eng*, 48: 169-175, https://doi.org/10.1016/S0260-8774 (00)00154-0.

Mastud, S.K, Mote, G.V., Sahoo, AK. (2018). Development of value added products by using purslane (*Portulaca oleracea*). *J Pharmacog and Phytochem,* 7(4): 1761-1766.

Mousavi, M., Heshmati, A., Garmakhany, A.D., Vahidinia, A., Taheri, M. (2019). Optimization of the viability of Lactobacillus acidophilus and physico-chemical, textural and sensorial characteristics of flaxseed-enriched stirred probiotic yogurt by using response surface methodology. *LWT - Food Sci. Technol,* 102: 80–88, https://doi.org/10.1016/j.lwt.2018.12.023.

Oliveira, I., Valentão, P., Lopes, R., Andrade, P.B., Bento, A., Pereira, J.A. (2009). Phytochemical characterization and radical scavenging activity of *Portulaca oleraceae* L. leaves and stems. *Microchem J,* 92: 129–134, doi:10.1016/j.microc.2009.02.006.

Orikasa, T., Koide, S., Okamoto, S., Imaizumi, T., Muramatsu, Y., Takeda, J., Shiina, T., Tagawa, A. (2014). Impacts of hot air and vacuum drying on the quality attributes of kiwifruit slices. *J Food Eng,* 125: 51–58, doi: 10.1016/j.jfoodeng.2013.10.027.

Vital, A.C.P., Priscila Akie Goto, P.A., Hanai, L.N., Gomes-da-Costa, S.M., Benício, A.A.F., Nakamura, C.V., Matumoto-Pintro, P.T. (2015). Microbiological, functional and rheological properties of lowfat yogurt supplemented with *Pleurotus ostreatus* aqueous extract. *LWT - Food Sci Technol*, 64: (2), 1028-103, https://doi.org/10.1016/j.lwt.2015.07.003.

Pathare, P.B., Opara, U.L., Al-Julanda Al-Said, F. (2013). Colour measurement and analysis in fresh and processed foods: A review. *Food Bioprocess Technol*, *6*: 36–60, doi: 10.1007/s11947-012-0867-9.

Ramirez-Santiago, C., Ramos-Solis, L., Lobato-Calleros, C., Peña-Valdivia, C., Vernon-Carter, E.J. Alvarez-Ramírez, J. (2010). Enrichment of stirred yogurt with soluble dietary fiber from *Pachyrhizus erosus* L. Urban: Effect on syneresis, microstructure and rheological properties. *J Food Eng,* 101, 229–235, doi:10.1016/j.jfoodeng. 2010.06.023.

Robitaille, G., Tremblay, A., Moineau, S., St-Gelais, D., Vadeboncoeur, C., Britten, M. (2009). Fat-free yogurt made using a galactose-positive exopolysaccharide-producing recombinant strain of *Streptococcus thermophilus*. *J. Dairy Sci.* 92: 477–482, https://doi.org/10.3168/jds.2008-1312.

Rudra, S.G., Nath, P., Kaur, C., Basu, S. (2017). Rheological, storage stability and sensory profiling of low-fat yoghurt fortified with red capsicum carotenoids and inulin. *J Food Process and Preserve,* 41: e13067, doi:10.1111/jfpp.13067.

Renner, E. 1993. *Milchprakticum*. Justus-Liebig-Universitat, Giessen, Germany.

Sagar, V.R., Suresh Kumar, P. (2010). Recent advances in drying and dehydration of fruits and vegetables: a review. *J Food Sci Technol*, 47: 15-26.

Sanz, T., Salvador, A., Jime´nez, A., Fiszman, S.M. (2008). Yogurt enrichment with functional asparagus fibre. Effect of fibre extraction method on rheological properties, colour, and sensory acceptance. *Eur Food Res Technol*, 227:1515–1521, doi: 10.1007/s00217-008-0874-2.

Seckin, A.K., Baladura, E. (2012). Effect of using some dietary fibers on color, texture and sensory properties of strained yogurt. *GIDA*, 37(2): 63-69.

Sert D, Evkaya, M. (2017). Semizotunun yoğurtta kullanım olanağının araştırılması. Ankara Üniversitesi Ziraat Fakültesi 13. Öğrenci Kongresi, Ankara, Türkiye.

Sigdel, A., Ojha, P., Karki, T.B. (2018). Phytochemicals and syneresis of osmo-dried mulberry incorporated yoghurt. *Food Sci Nutr*, 6: 1045-1052, doi: 10.1002/fsn3.645.

Tamime, A. Y., Robinson, R.K. (2007). *Yoghurt: Science and Technology*. 3rd ed. *CRC Press*, Boca Raton, FL.

Tarakci, Z., Temiz, H., Ugur, A. (2011). The effect of adding herbs to labneh on physicochemical and organoleptic quality during storage. *Int J Dairy Technol,* 64(1): 108-116, doi: 10.1111/j.1471-0307.2010.00636.x.

Wainstein, J., Landau, Z., Dayan, Y.B., Jakubowicz, D., Grothe, T., Perrinjaquet-Moccetti, T., Boaz, M. (2016). Purslane extract and glucose homeostasis in adults with type 2 diabetes: a double-blind, placebo-controlled clinical trial of efficacy and safety. *J Med Food* 19 (2): 133–140, doi:10.1089/Jmf.2015.0090.

Wang, X., Kristo, E., LaPointea, G. (2019). The effect of apple pomace on the texture, rheology and microstructure of set type yogurt. *Food Hydrocoll*, 91:83-91, https://doi.org/10.1016/j.foodhyd.2019.01.004.

Wu, X., Wang, J., Hou, N. (2011). Techniques of making purslane yogurt. *Tianjin Agric Sci.* 2011:1.

Yan, J., Sun, L., Zhou, Z., Chen, Y., Zhang, W., Dai, H., Tan, J. (2012). Homoisoflavonoids from the medicinal plant *Portulaca oleracea*. *Phytochemistry, 80*: 37–41, doi: 10.1016/j.phytochem.2012.05.014.

Youssef, KM, Mokhtar, SM. (2014). Effect of drying methods on the antioxidant capacity, color and phytochemicals of *Portulaca oleracea* L. leaves. *J Nutr Food Sci* 4: 322, doi: 10.4172/2155-9600.1000322.

Zakizadeh, E., Faghihimani E., Saneei, P., Esmaillzadeh, A. (2015). The effect of purslane seeds on biomarkers of oxidative stress in diabetic patients: A randomized controlled cross-over clinical trial. *Int J Prev Med.*, 6: 95, doi: 10.4103/2008-7802.166505.

Zhou, Y., Xin, H., Rahman, K., Wang, S., Peng, C., Zhang, H. (2015). *Portulaca oleracea* L: A review of phytochemistry and pharmacological effects. *Hindawi Publishing Corporation BioMed Res Int*, 11,doi: 10.1155/2015/925631.