DOI:10.22059/IJVM.2022.339182.1005249 **Iranian Journal of Veterinary Medicine** **Original Article**

Online ISSN: 2252-0554

Antioxidant, Syneresis and Sensory Characteristics of Probiotic Yogurt Incorporated with *Agave tequilana* Aqueous Extract

…

Melika Farzaneh[1], Vajiheh Fadaei [1*], Hassan Gandomi Nasrabadi[2]

[1] Department of Food Science and Technology, Shahr-e-Qods Branch, Islamic Azad University, Tehran, Iran.

[2] Department of Food Hygiene and Quality Control, Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran.

Running title: Antioxidant effect of agave extract in yogurt

Abstract

BACKGROUND: The growing consumer interest in healthy food has encouraged the industry to search for food products the exhibit additional functional effects over nutritional value. Yogurt is the best carrier for beneficial nutrients such as probiotics and antioxidants. *Agave tequilana* is a plant that contains phytochemicals comprising flavonoids that show antioxidant activity.

OBJECTIVES: In this work, the effects of incorporation of *Agave tequilana* Aqueous Extract (ATAE) on antioxidant, syneresis and sensorial properties of probiotic yogurt were investigated.

METHODS: Radical scavenging ability was evaluated against the DPPH (2,2-diphenyl-1-picrylhydrazyl). Amounts of total phenolic compounds (TPC) were determined using the Folin Ciocalteu method. Syneresis was determined using the centrifugal technique. The sensory evaluation was carried out using a five-point hedonic scale.

RESULTS: The addition of ATAE in yogurts exhibited a dose-dependent relationship and had significantly ($P \leq 0.05$) higher TPC and DPPH scavenging ability than control yogurts. The value of TPC and DPPH scavenging ability of 0.5, 1, and 1.5% ATAE-fortified yogurts were 389.9, 629.2 and 905.6 mg GAE/kg yogurt and 283, 480, and 617 mgBHT eq./kg yogurt, respectively.

The addition of ATAE increased syneresis of yogurt samples ($P \leq 0.05$). Although the sensory properties of symbiotic yogurt samples were lower than plain and probiotic treatments, their scores were still above the acceptable level.

CONCLUSIONS: As the results of this study indicated improvement of antioxidant properties of the yogurt incorporated with AEAT, its potential application as a functional food formulation is recommended.

Keywords: Synbiotic yogurt; *Agave tequilana* extract; Antioxidant activity; Total phenol; syneresis.

Introduction

Agave tequilana is a plant of an angiosperm species that belongs to the family *Asparagaceae.* It is commonly used for the production of Tequila, an alcoholic beverage (López and Urías-Silvas, 2007). Several biological properties, including antibacterial, antioxidant and anti-inflammatory properties of this plant are reported (Sahnoun *et al.,* 2017). Some agave species demonstrated antioxidant activity (Romero-Lopez *et al.,* 2015). Agave syrup contains phytochemicals comprising flavonoids, polycosanols and sapogenins, which show anticarcinogen and antioxidant activity (Narvaez-Zapata and Sanchez-Teyer, 2009). *Agave* juice is used for the production of syrup and fructooligosaccharides (FOS) powder due to its high content of fructans (Salazar-

Leyva *et al.,* 2016). Fructans are the principal photosynthetic composition of this plant (Lopez *et al.,* 2003). Fructans are used as food ingredients including sweeteners, texture modifiers, and fat-replacer in food products (Salazar-Leyva *et al.,* 2016). The prebiotic effect of agave fructans have been well known by several researches (López and Urías-Silvas, 2007; Marquez-Aguirre *et al.*, 2013; Ramnani *et al.,* 2015; Urias-Silvas *et al.*, 2008; Zamora-Gasga *et al.*, 2015).

In recent years, consumers are concerned about the beneficial value of food and are seeking healthier options (Kowaleski *et al*., 2020). This growing consumer interest in healthy food has encouraged the industry to search and develop food products that show additional functional/health effects over common nutritional values. Antioxidants such as polyphenols and carotenoids are popular functional ingredients that represent different health benefits including anti-cancer, eye-protective, heart-protective and anti-diabetic properties. Furthermore, probiotic food products are among the most popular functional foods marketed worldwide. The growing consumer interest in probiotic products is because probiotic microorganisms exhibit different health benefits to human by improving lactose digestion, preventing intestinal infections, preventing cancers, modulating the immune system and lowering cholesterol (Aryana and Mc Grewa, 2007).

Yogurt is the most popular fermented dairy product market in the world due to its therapeutic, nutritional, and sensory properties. From a nutritional point of view, yogurt is a nutrient-dense food, as it contains protein, riboflavin, vitamins B6 and B12, and calcium. Yogurt and fermented milk products are among the best carrier of beneficial nutrients such as probiotics and antioxidants (O'Sullivan *et al*., 2016).

In this research, the effect of ATAE in levels 0.5, 1 and 1.5% was investigated on selected physicochemical and sensory properties of probiotic yogurt during the storage

Material and methods

Preparation of *Agave tequilana* aqueous extract

The *A. tequilana* was prepared from a plant garden in Tehran province of Iran. All the leaves were cut into small pieces and dried for two weeks in the shade at environmental temperature. It was then comminuted using a mechanical grinder (Moulinex, Paris, France). For extract preparation, 50 g of the grinded plant was soaked in 450 mL water and let shake for 48 h at 250 rpm, followed by filtration through filter paper of Whatman No. 1, then vaporized at 50 °C using a rotary evaporator (Buchi Rotavapor R-114, Switzerland) and further dried at 40 °C. The extract powder was refrigerated at 4 °C till running the experiments (Dahikar *et al.,* 2010).

Preparation of probiotic bacteria

The probiotic bacteria including *Lactobacillus acidophilus* (La5) and *Bifidobacterium bifidum* (Bb-12) prepared from CHR Hansen (Horsholm, Denmark) were used in this study. Freeze-dried bacteria were added to the sterile MRS-Broth medium and incubated for 48 h at 37 ° C in aerobic conditions and anaerobic jar for *L. acidophilus* and *B. bifidum,* respectively. Bacterial cultures were harvested by centrifugation at 4000 ×g at 4 °C for 10 min and washed twice with sterile saline and collected by centrifugation. A bacterial suspension with optical density (OD) of 0.1 at 600 nm was prepared and the cell numbers were determined using the surface plate count technique by preparing serial dilutions and plating on MRS agar. The plates were then incubated at 37 °C for 3 days in aerobic and anaerobic conditions for *L. acidophilus* and *B. bifidum,* respectively, as mentioned above. The bacterial number was calculated by colony counter.

Yogurt preparation

Yogurts (set style) were made from cow's milk contains 1.5% (w/w) fat and 12 % (w/v) total solids. Raw milk was treated at 85 °C for 15 min, and then cooled to 42°C (for fermentation). All cultures were used according to the manufacturer's instructions. Milk was inoculated with yogurt starters, *Streptococcus thermophilus* and *Lactobacillus bulgaricus*, (Delvo, USA) and probiotic cultures (10^8 cfu/ml) and mixed thoroughly; immediately ATAE (0, 0.5, 1 and 1.5%) was added to the milk and incubated at 42 °C. A plain yogurt without probiotic bacteria and AEAT was prepared as control. Fermentation continued up to the pH of 4.5 ± 0.02. After fermentation, yoghurt samples were cooled to 4 °C and stored at this temperature for 21 days.

Physicochemical and sensory analysis

Syneresis was determined using a centrifuge by Najgebauer-Lejko *et al.* (2014) and Sahan *et al.* (2008) methods. syneresis extent was calculated as the weight percentage of whey released after centrifugation.

Total phenolics content (TPC) was estimated using Folin- Ciocalteu reagent and Gallic acid as standard as described by Shori and Baba, (2013).

Determination of radical scavenging activity was done by DPPH method (Brand-Williams et al., 1995) were evaluated. TPC was measured as described by Shori and Baba, (2013). BHT was used as a standard antioxidant and the antioxidant activity of the yogurt samples was expressed as mg BHT equivalent/kg yogurt.

A panel composed of 5 experienced members was used to evaluate the yogurts characteristics for appearance, flavor, texture, and overall acceptability with a point scale from 0 to 5 (0 means s unacceptable).

All analyses were performed on the first, 7th and 21st days of storage.

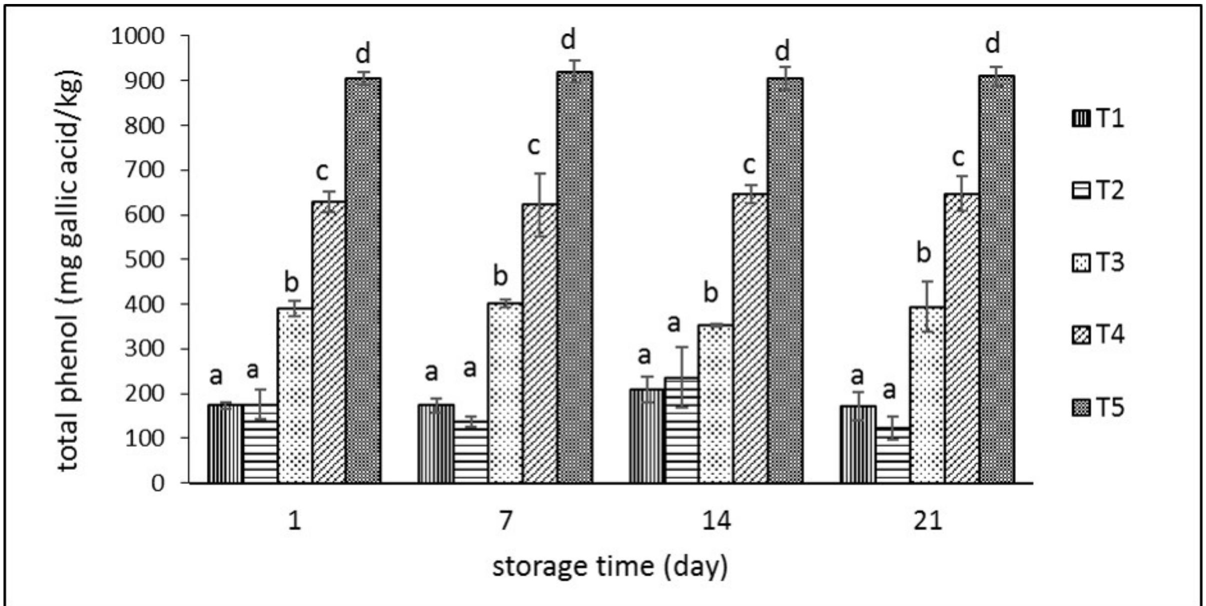
Statistical analysis

Statistics on a completely randomized design were performed with the analysis of variance (ANOVA) procedure using SPSS 20 (Chicago, IL, USA). Duncan test was used to compare the difference among mean values at the significant level of 0.05 ($p<0.05$). All experiments were replicated three times.

Results

According to Figure 1, the presence of ATAE caused a significant increase of TPC in the yogurts ($P \leq 0.05$); at day 1, the lowest and highest TPC were observed in T3 (389.9 mg gallic acid/ kg) and T5 (905.6 mg gallic acid/ kg), respectively. The lowest TPCs were observed in control probiotic yogurt (175.2 mg gallic acid/ kg) and plain yogurt sample (173.2 mg gallic acid/ kg), respectively, without any significant difference with each other ($P > 0.05$). Storage did not cause the significant increase of TPC in the yogurts ($P > 0.05$).

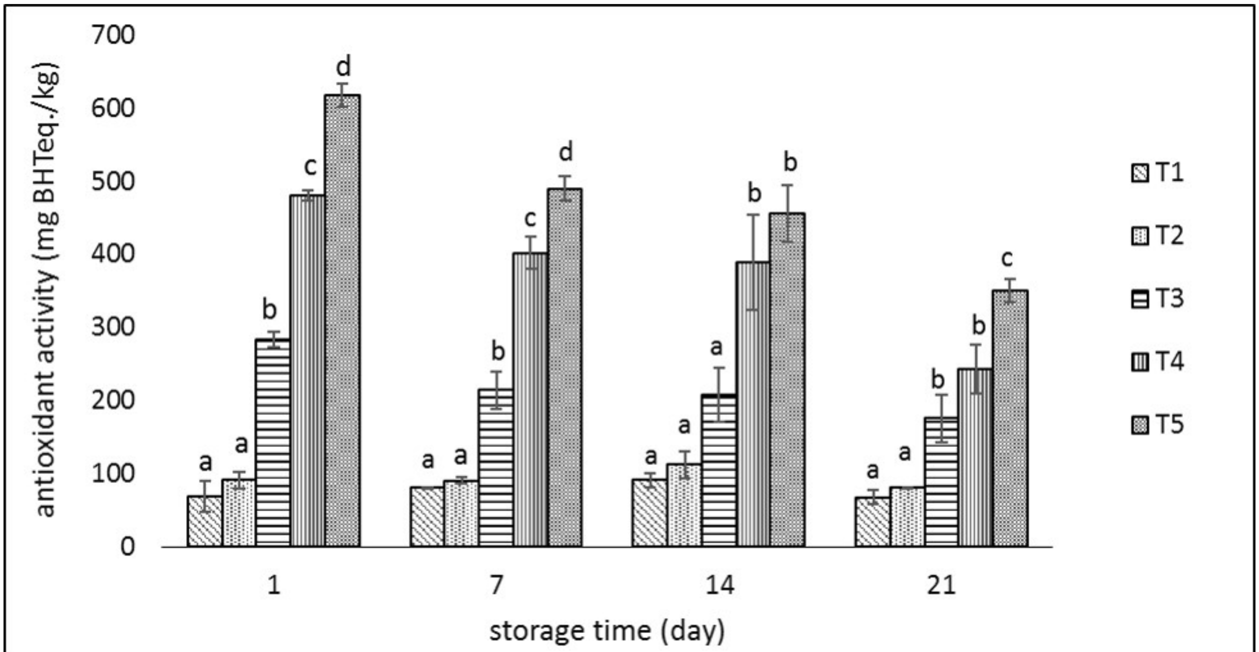
Figure 1 TPC of yogurt containing ATAE during storage.



T1: plain yogurt, T2: probiotic yogurt, T3: synbiotic yogurt containing 0.5% AEAT, T4: synbiotic yogurt containing 1% AEAT, T5: synbiotic yogurt containing 1.5% AEAT. Different letters show statistically significant between different treatments at each day ($p<0.05$).

As shown in Figure 2, the antioxidant activity (AA) increases with increasing ATAE concentration ($P\leq 0.05$). The AA of plain yogurt was measured 69 mg BHT eq./kg on day 1 which remained constant during the storage. During 21 days of storage, no statistically significant difference was observed in AA of the control probiotic yogurt compared to plain yogurt ($P > 0.05$). The AA was decreased during the time ($P\leq 0.05$).

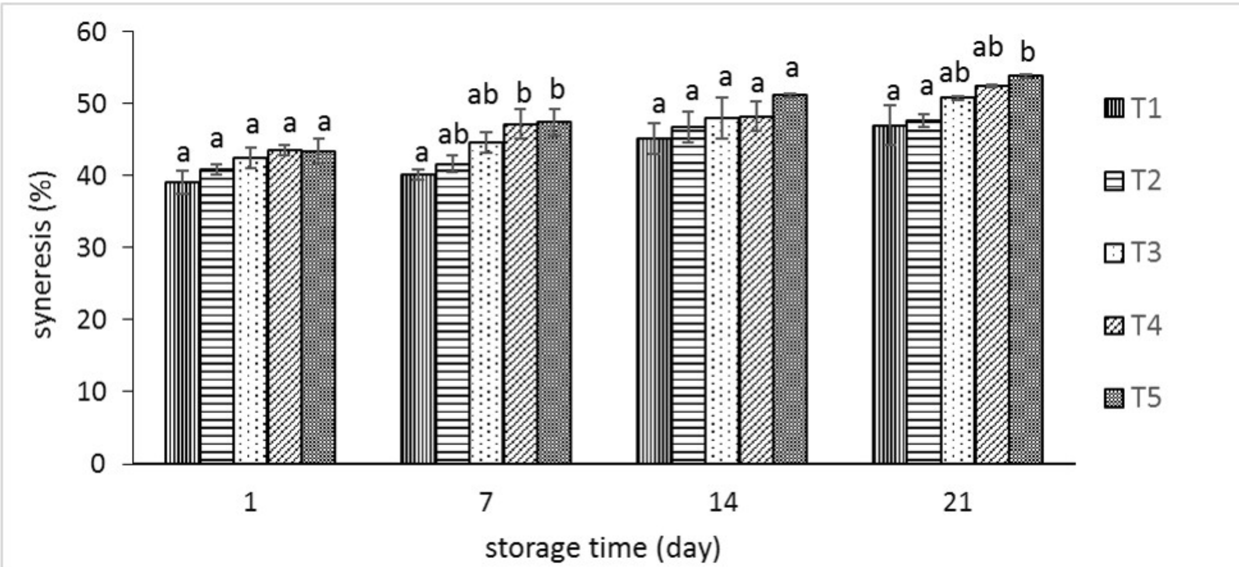
Figure 2 AA (mg BHT eq./kg) of synbiotic yogurt containing ATAE during storage.



T1: plain yogurt, T2: probiotic yogurt, T3: synbiotic yogurt containing 0.5% AEAT, T4: synbiotic yogurt containing 1% AEAT, T5: synbiotic yogurt containing 1.5% AEAT. Different letters show statistically significant between different treatments at each day ($p<0.05$).

The results of syneresis of the yogurt samples during the storage are indicated in Figure 3. The plain yogurt showed 39.1% syneresis on the first day, which increased to 47% on day 21. No statistically significant difference was found in syneresis of probiotic yogurt compared to plain yogurt ($P > 0.05$), however the syneresis was enhanced during the time.

Figure 3 Syneresis (%) of synbiotic yogurt containing ATAE during storage.



T1: plain yogurt, T2: probiotic yogurt, T3: synbiotic yogurt containing 0.5% AEAT, T4: synbiotic yogurt containing 1% AEAT, T5: synbiotic yogurt containing 1.5% AEAT. Different letters show statistically significant between different treatments at each day ($p<0.05$).

The results of the organoleptic assessment of the yogurt samples are shown in Table 1. The sensory properties of the probiotic yogurt including appearance, flavor, texture, and overall acceptability were comparable to the plain yogurt. Addition of AEAT induced significant darkening of the yogurt compared to the control yogurt ($P \leq 0.05$), and this effect was concentration dependent. Furthermore, an extract flavor was found by panelists in synbiotic yogurt containing different concentrations of AEAT. The symbiotic yogurt showed less softness and consistency compared to control yogurt ($P \leq 0.05$).

Table 1 Organoleptic characteristics of synbiotic yogurt containing ATAE during storage.

treatment	appearance	flavor	texture	Overall acceptance
T1	4.9 ± 0.32^{a}	5 ± 0.00 ^{a}	5 ± 0.00 ^{a}	4.8 ± 0.42 ^{a}
T2	4.8 ± 0.42^{a}	4.9 ± 0.32^{a}	4.9 ± 0.67 ^{a}	4.8 ± 0.42 ^{a}
T3	4.1± 0.57^{b}	4.3 ± 0.82^{b}	4 ± 0.67 ^{b}	3.9 ± 0.57 ^{b}
T4	3.4± 0.52^{c}	3.2 ± 0.63 ^{c}	3.3 ± 0.32 ^{c}	3.2 ± 0.63 ^{c}
T5	3± 0.47^{c}	3 ± 0.32 ^{c}	3.1 ± 0.32 ^{c}	3 ± 0.53 ^{c}

T1: plain yogurt, T2: probiotic yogurt, T3: synbiotic yogurt containing 0.5% AEAT, T4: synbiotic yogurt containing 1% AEAT, T5: synbiotic yogurt containing 1.5% AEAT. Different superscript letters at each column show statistically significant between different treatments ($P < 0.05$).

Discussion

Several studies have reported increase of phenolic content in yogurt due to fortification with different plant extracts (Farvin *et al.*, 2010; Mosiyani, 2017; Shori, 2013; Shori and Baba, 2013). In the present study, the polyphenol content of the yogurt samples did not change during the storage. It seems that the effect of storage time depends on the several factors including bacterial ability to metabolized polyphenols (Shori and Baba, 2013) and the extent of interaction between phenolic compounds and proteins; the more connection between phenolic and proteins the more decrease in phenolic recovery during the time as reported by Vital *et al.* (2015).

It is reported that the AA of the yogurt is associated to the release of a large number of peptides and amino acids by lactic acid bacteria during fermentation of the milk (Farvin *et al.*, 2010; Kudoh *et al.,* 2001; Madhu *et al.,* 2012; Pena-Rasmos *et al.*, 2004). The results revealed a direct relationship between TPC and AA in 0.5, 1, and 1.5% ATAE-fortified yogurts. Increases in AA of the plant preparations is related to the TPC content of their composition (Muniandy *et al.*, 2016; Vasco *et al.,* 2008). An increase in the concentration of ATAE induced an increase in AA; the value of DPPH scavenging ability of 0.5, 1, and 1.5% ATAE-fortified yogurts was 283, 480, and 617 mgBHT eq./kg yogurt, respectively. This is in accordance with other studies, which have shown that incorporation of different sections of the plant and fruit detect a significant difference between AA of yogurts fortified with them and that of the control (El-Said *et al.,* 2014; Yadav *et al.,* 2018; Hashemi *et al.,* 2016; stevia; de Carvalho *et al.,* 2019; Liu, 2018; Gaglio *et al.,* 2019; Shori and Baba, 2013; Shori, 2013; Mosiyani *et al.,* 2017). However, the antioxidant effects of the synbiotic yogurt samples showed a significant decrease up to 50% after 21 days of storage. Decrease in antioxidant activity of yogurts during storage were reported by many studies (Jozve-zargharabadi *et al*., 2020; Cho *et al*., 2020; Bchir *et al*., 2019; Kim *et al*., 2019; Mosyani *et al.,* 2017; Oh *et al.,* 2016). This may be resulted from the formation of a complex between polyphenols and milk proteins (Kim *et al*., 2019; Bchir *et al*., 2019; Oksuz *et al*., 2019; Sánchez-Bravo *et al*., 2018; Helal *et al*., 2018; Lamothe *et al.*, 2014).

Addition of AEAT to the probiotic yogurt significantly elevated syneresis extent compared to the plain yogurt and probiotic control yogurt ($P \leq 0.05$). This result is in agreement with results obtained by Michael *et al.* (2010), Faraki *et al.* (2020), Sengul and Yildiz (2012), and Ramirez-Santiago *et al.* (2010), who found that olive, garlic, onion and citrus extracts, *Auricularia auricula* aqueous extract, sour cherry pulp, and *Pachyrhizus erosus L* fibers, respectively, in yogurts led to an increase in syneresis. The increase of whey expulsion from the yogurt may be explained by weakening casein network due to interaction with active groups of the extract, thermodynamic incompatibility between polysaccharide of the extract and milk proteins, and unbalanced osmotic potential due to depletion flocculation of the casein micelles in the presence of non-adsorbing polymers such as dietary fiber (Michael *et al.*, 2010). The polyphenol-protein interaction which played an important role in serum separation depends on various factors including proteins and polyphenol nature, temperature, and presence of other bioactive compounds (Vital *et al.*, 2015). However, this observation is not in line with results of Huang *et al.* (2020), Guo *et al.* (2018), Amirdivani *et al.* (2013) and Narayana and Gupta, (2013), who demonstrated positive effect of the plant preparations on the decrease of syneresis. Increased syneresis in the yogurt samples over storage time can be explained by protein re-arrangement, which weaken the casein network (Everett and Mcleod, 2005). The increase of syneresis during the storage time was reported earlier (Alighazi *et al*., 2021; Amirdivani *et al.,* 2013; Zare *et al.,* 2011).

The reduction of organoleptic acceptability of the yogurt incorporated by red ginseng extract (Jung *et al*., 2016), *Hibiscus sabdariffa* (Iwalokun and Shittu, 2007), aqueous extract of basil and savory (Mosyani *et al.,* 2017), *Chlorella vulgaris* and *Arthrospira platensis* (Beheshtipour and Motazavian, 2012) and green tea extract (Shokery *et al.,* 2017) was reported. However, some experiments showed improvement of sensorial parameters of yogurt which was fortified by soybean extract (Park and Oh, 2007), agave fructans (Crispín-Isidro *et al.,* 2014), grape and callus extracts (Karaaslan *et al.,* 2011), and cinnamon ethanol extract (Jin *et al.,* 2016). Although, the overall acceptability of synbiotic yogurt containing AEATwas lower than that of plain and probiotic control yogurt, they were still acceptable.

Conclusion

In this study, we presented a novel functional yogurt by incorporating ATAE to probiotic yogurt. The results of this study showed a significant increase in TPC and AA of yogurt by addition of AEAT. Generally, our results proposed use of this yogurt formulation as a functional product for improving consumer health. However, as addition of the extract increased syneresis and impaired sensorial acceptance of the yogurt, investigations on the application of encapsulated *A. tequilana* extract in symbiotic yogurt is recommended.

Acknowledgment

The authors wish to thank the Mabna Tashkhis Laboratory staffs for their hospitality and technical assistance in this program.

Conflict of Interest

The authors declared no conflict of interest.

References

Alighazi N. Noori N. Gandomi H. & Akhondzadeh Basti A. A. (2021). Effect of ziziphora clinopodioides essential oil stress on viability of *Lactobacillus acidophilus* and *Bifidobacterium bifidum* microencapsulated with alginate-chitosan and physicochemical and sensory properties of probiotic yoghurt. *Iranian Journal of Veterinary Medicine*, 15(2), 234-253. [DOI: 10.22059/ijvm.2020.303329.1005092]

Amirdivani S. & Baba A. S. (2013). Rheological properties and sensory characteristics of green tea yogurt during storage. *Life Science Journal,* 10, 378-390.

Aryana K. J. & Mc Grewa P. (2007) Quality attributes of yogurt with *Lactobacillus casei* and various prebiotics. *LWT - Food Science and Technology,* 40(10), 1808-1814. [DOI:10.1016/j.lwt.2007.01.008]

Bchir, B. Bouaziz, M. A. Blecker, C. & Attia, H. (2019). Physico-Chemical, antioxidant activities, textural, and sensory properties of yoghurt fortified with different states and rates of pomegranate seeds (*Punica granatum L.*). *Journal of Texture Studies*, 6, 1-9. [DOI:10.1111/jtxs.12500]

Brand-Williams, W., Cuvelier, M.E. & Berset, C. L. W. T. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT - Food Science and Technology,* 28(1), 25-30. [DOI:10.1016/S0023-6438(95)80008-5]

Beheshtipour H., Mortazavian A. M., Haratian P. & Khosravi Darani K. (2012). Effects of *Chlorella vulgaris* and *Arthrospira platensis* addition on viability of probiotic bacteria in yogurt and its biochemical properties. *European Food Research and Technology*, 235, 719–728. [DOI:10.1007/s00217-012-1798-4]

Cho, W. Y. Kim, D. H. Lee, H. J. Yeon, S. J. & Lee, C H. (2020). Quality characteristic and antioxidant activity of yogurt containing olive leaf hot water extract. *CyTA – Journal of Food*, *18*(1), 43-50.

[DOI:10.1080/19476337.2019.1640797]

Crispin-Isidro G., Lobato-Calleros C., Espinosa-Andrews H., Alvarez-Ramirez J. & Vernon-Carter E. J. (2014). Effect of inulin and agave fructans addition on the rheological, microstructural and sensory properties of reduced-fat stirred yogurt. *LWT - Food Science and Technology,* 42, 1-7**.** [DOI:10.1016/j.lwt.2014.06.042]

Dahikar S. B., Bhutada S. A., Vibhute S. K., Sonvale V. C., Tambekar D. H. & Kastur S. B. (2010). Evaluation of antibacterial potential of *Trikatu churna* and its ingredients: An in vitro study. *International Journal of Phytomedicine,* 2, 412-417.

de Carvalho M. W., Arriola N. D. A., Pinto S. S., Verruck S., Fritzen-Freire C. B., Prudencio E. S., de Mello R. D. & Amboni C. (2019). Stevia-fortified yoghurt: Stability, antioxidant activity and in vitro digestion behavior. *International Journal of Dairy Technology*, 72(1), 57-64. [DOI:10.1111/1471-0307.12559]

El-Said M. M., Haggag H. F., El-Dina H. M. F., Gad A. S. & Farahat A. M. (2014). Antioxidant activities and physical properties of stirred yoghurt fortified with pomegranate peel extracts. *Annals of Agricultural Sciences,* 59(2), 207-212. [DOI:10.1016/j.aoas.2014.11.007]

Everett D. W. & McLeod R. E. (2005). Interactions of polysaccharide stabilizers with casein aggregates in stirred skim-milk yoghurt. *International Dairy Journal*, 15(11), 1175-1183. [DOI:10.1016/j.idairyj.2004.12.004]

Faraki A., Noori N., Gandomi H., Banuree S. A. H. & Rahmani F. (2020). Effect of *Auricularia auricula* aqueous extract on survival of *Lactobacillus acidophilus* La-5 and *Bifidobacterium bifidum* Bb-12 and on sensorial and functional properties of synbiotic yogurt. *Food Science and Nutrition,* 8(2), 1254-1263.

[DOI:10.1002/fsn3.1414]

Farvin S., Baron C., Skall N. & Jacobsen C. (2010). Antioxidant activity of yoghurt peptides: part 1-in vitro assays and evaluation in omega-3 enriched milk. *Food Chemistry,* 123(4), 1081–1089.

[DOI:10.1016/j.foodchem.2010.05.067]

Gaglio R., Gentile C., Bonanno A., Vintaloro L., Perrone A., Mazza F., Barbaccia P., Settanni L., & Grigoli A. D. (2019). Effect of saffron addition on the microbiological, physicochemical, antioxidant and sensory characteristics of yoghurt. *International Journal of Dairy Technology,* 72(2), 208-217.

[DOI:10.1111/1471-0307.12569]

Guo X., Xie Z., Wang G., Zou Q. & Tang R. (2018). Effect on nutritional, sensory, textural and microbiological properties of low-fat yoghurt supplemented with *Jerusalem artichoke* powder. *International Journal of Dairy Technology,* 71(S1), 167-174.

[DOI:10.1111/1471-0307.12404]

Hashemi S. M. B., Aminınezhad R., Shirzadinezhad E., Farahani M. & Yousefabad S. H. A. (2016). The antimicrobial and antioxidant effects of *Citrus aurantium* L. flowers (Bahar Narang) extract in traditional yoghurt stew during refrigerated storage. *Journal of Food Safety,* 36(2), 153-161.

[DOI:10.1111/jfs.12222]

Helal, A. & Tagliazucchi, D. (2018). Impact of in-vitro gastro-pancreatic digestion on polyphenols and cinnamaldehyde bioaccessibility and antioxidant activity in stirred cinnamon-fortified yogurt. *LWT-Food Science and Technology, 89*, 164-170.

[DOI:10.1016/j.lwt.2017.10.047]

Huang Y., Zhao S., Yao K., Liu D., Peng X., Huang J., Huang Y. & Li L. (2020). Physicochemical, microbiological, rheological, and sensory properties of yoghurts with new polysaccharide extracts from *Lactarius volemus* Fr. using three probiotics. *International Journal of Dairy Technology*, 73(1), 168-181.

[DOI:10.1111/1471-0307.12653]

Iwalokun B. A. & Shittu M. O. (2007). Effect of *Hibiscus Sabdariffa* (Calyce) extract on biochemical and organoleptic properties of yogurt. *Pakistan Journal of Nutrition,* 6(2), 172-182.

[DOI:10.3923/pjn.2007.172.182]

Jin H. J., Yang H. S., Lee S. C. & Huh C. K. (2016). Quality and storage characteristics of yogurt containing *Lacobacillus sakei* ALI033 and cinnamon ethanol extract. *Journal of Animal Science and Technology,* 58(16), 2-7.
[DOI:10.1186/s40781-016-0098-0]

Jozve-Zargarabadi, E. Fadaei-Noghani, V. & Fallah Huseini, H. (2020). Viability of starter bacteria and anti-Oxidative activity of a functional yogurt containing *Silybum marianum* seed extract. *Applied Food Biotechnology*, *7*(3), 135-142.
[DOI: 10.22037/afb.v7i3.26998]

Jung J., Paik H. D., Yoon H. J., Jang H. J., Jeewanthi R. K. C., Jee H. S., Li X., Lee N. K., & Lee S. K. (2016). Physicochemical characteristics and antioxidant capacity in yogurt fortified with red Ginseng extract. *Korean Journal for Food Science of Animal Resources,* 36(3), 412-420.
[DOI:10.5851/kosfa.2016.36.3.412]

Karaaslan M., Mustafa M., Vardin H. & Turkoglu H. (2011). Phenolic fortification of yogurt using grape and callus extracts. *LWT - Food Science and Technology,* 44, 1065-1072.
[DOI:10.1016/j.lwt.2010.12.009]

Kim, D. H. Cho, W. Y. Yeon, S. J. Choi, S. H. & Lee, C. H. (2019). Effects of Lotus (*Nelumbo nucifera*) leaf on quality and antioxidant activity of yogurt during refrigerated storage. *Food Science of Animal Resources,* 39 (5), 792-803.

[DOI:10.5851/kosfa.2019.e69]

Kowaleski J., Quast L. B., Steffens J., Lovato F., dos Santos L. R., da Silva S. Z., de Souza D. M. & Felicetti M. A. (2020). Functional yogurt with strawberries and chia seeds. *Food Bioscience,* 37, 100726.

[DOI:10.1016/j.fbio.2020.100726]

Kudoh Y., Matsuda S., Igoshi K. & Oki T. (2001). Antioxidative peptide from milk fermented with *Lactobacillus delbrueckii subsp. bulgaricus* IFO13953. *Journal of the Japanese Society for Food Science and Technology,* 48(1), 44-50.

[DOI:10.3136/nskkk.48.44]

Lamothe S., Azimy N., Bazinet L., Couillard C. & Britten M. (2014). Interaction of green tea polyphenols with dairy matrices in a simulated gastrointestinal environment. *Food and Function,* 5(10), 2621-2631.

[DOI:10.1039/C4FO00203B]

Liu D. (2018). Effect of Fuzhuan brick-tea addition on the quality and antioxidant activity of skimmed set-type yoghurt. *International Journal of Dairy Technology,* 71, 22-33.

[DOI:10.1111/1471-0307.12395]

Lopez M. G., Mancilla-Margalli N. A. & Mendoza-Dıaz G. (2003). Molecular structures of fructans from *Agave tequilana* Weber var. azul. *Journal of Agricultural and Food Chemistry,* 51, 7835–7840.

[DOI:10.1021/jf030383v]

López M. G. & Urías-Silvas J. E. (2007). Agave fructans as prebiotics In: *Recent Advances in Fructooligosaccharides Research*, pp 645-662, Shiomi N, Benkeblia N and Onodera S, ed. Trivandrum, Kerala, India.

[DOI:10.1897/07-302]

Madhu A. N., Amrutha N. & Prapulla S. G. (2012). Characterization and antioxidant property of probiotic and synbiotic yogurts. *Probiotics and Antimicrobial Proteins,* 4(2), 90-97.

[DOI:10.1007/s12602-012-9099-6]

Marquez-Aguirre A. L., Camacho-Ruiz R. M., Arriaga-Alba M., Padilla-Camberos E., Kirchmayr M. R., Blasco J. L. & Gonzalez-Avila M. (2013). Effects of *agave tequilana* fructans with different degree of polymerization profiles on the body weight, blood lipids and count of fecal Lactobacilli/ Bifidobacteria in obese mice. *Food and Function,* 4, 1237-1244.

[DOI:10.1039/C3FO60083A]

Michael M., Phebus R. K. & Schmidt K. A. (2010). Impact of a plant extract on the viability of *Lactobacillus delbrueckii ssp. Bulgaricus* and *Streptococcus thermophilus* in nonfat yogurt. *International Dairy Journal*, 20, 665-672.

[DOI:10.1016/j.idairyj.2010.03.005]

Mosiyani Z. G., Pourahmad R. & Eshaghi M. R. (2017). Investigating the effect of aqueous extracts of basil and savory on antioxidant activity, microbial and sensory properties of probiotic yogurt. *Acta Scientiarum Polonorum Technologia Alimentaria,* 16(3), 311-320.

[DOI:10.17306/J.AFS.2017.0509]

Muniandy P., Shori A. B. & Baba A. S. (2016). Influence of green, white and black tea addition on the antioxidant activity of probiotic yogurt during refrigerated storage. *Food Packaging and Shelf Life,* 8, 1-8.

[DOI:10.1016/j.fpsl.2016.02.002]

Najgebauer-Lejko D., Żmudziński D., Ptaszek A. & Socha R. (2014). Textural properties of yogurts with green tea and Pu-erh tea additive. *International Journal of Food Science and Technology*, 49(5), 1149-1158.

[DOI: 10.1111/ijfs.12411]

Narayana N. M. & Gupta V. K. (2013). Effect of total milk solid content adjusted by adding ultrafiltered milk retentate on quality of set mango yoghurt. *International Journal of Dairy Technology,* 66(4), 570-575.

[DOI:10.1111/1471-0307.12081]

Narvaez-Zapata J. A. & Sanchez-Teyer L. F. (2009). Agaves as a raw material: Recent technologies and applications. *Recent Patents on Biotechnology,* 3, 185-191.

[DOI:10.2174/187220809789389144]

Oh S. S., Lee J. Y., Joung J. Y., Kim K. S., Shin Y. K., Lee K. W., Kim S. H., Oh S. & Kim Y. (2016). Microbiological characterization and functionality of set-type yogurt fermented with potential prebiotic substrates *Cudrania tricuspidata* and *Moru alba* L. leaf extracts**.** *Journal of Dairy Science,* 99, 1–12.

[DOI:10.3168/jds.2015-10814]

Oksuz, T. Tacer-Caba, Z. Nilufer-Erdil, D. & Boyacioglu, D. (2019). Changes in bioavailability of sour cherry (*Prunus cerasus L.*) phenolics and anthocyanins when consumed with dairy food matrices. *Journal of Food Science and Technology*, 56 (9), 4177-4188.

[DOI:10.1007/s13197-019-03888-2]

O'Sullivan A. M., O'Grady M. N., O'Callaghan Y. C., Smyth T. J., O'Briena N. M. & Kerry J. P. (2016). Seaweed extracts as potential functional ingredients in yogurt. *Innovative Food Science and Emerging Technologies,* 37, 293–299.
[DOI:10.1016/j.ifset.2016.07.031]

Park K. B. & Oh S. H. (2007). Production of yogurt with enhanced levels of gamma-aminobutyric acid and valuable nutrients using lactic acid bacteria and germinated soybean extract. *Bioresource Technology,* 98, 1675–1679.
[DOI:10.1016/j.biortech.2006.06.006]

Pena-Rasmos E. A., Xiong Y. L. & Arteaga G. E. (2004). Fractionation and characterization for antioxidant activity of hydrolyzed whey protein. *Journal of the Science of Food and Agriculture,* 84, 1908–1918.
[DOI:10.1002/jsfa.1886]

Ramirez-Santiago C., Ramos-Solis L., Lobato-Calleros C., Peña-Valdivia C., Vernon-Carter E. J. & Alvarez-Ramirez J. (2010). Enrichment of stirred yogurt with soluble dietary fiber from *Pachyrhizus erosus* L. Urban: Effect on syneresis, microstructure and rheological properties. *Journal of Food Engineering,* 101(3), 229-235.

[DOI:10.1016/j.jfoodeng.2010.06.023]

Ramnani P., Costabile A., Bustillo A. G. R. & Gibson G. R. (2015). A randomized, double-blind, cross-over study investigating the prebiotic effect of agave fructans in healthy human subjects. *Journal of Nutritional Science,* 4, 1 -10.

[DOI:10.1017/jns.2014.68]

Romero-Lopez M. R., Osorio-Diaz P., Flores-Morales A., Robledo N. & Mora Escobedo R. (2015). Chemical composition, antioxidant capacity and prebiotic effect of aguamiel (*agave atrovirens*) during in vitro fermentation. *Revista Mexicana de Ingeniería Quimica,* 14(2), 281-292.

Sahan N., Yasar K. & Hayaloglu A. A. (2008). Physical, chemical and flavour quality of non-fat yogurt as affected by a β-glucan hydrocolloidal composite during storage. *Food Hydrocolloids,* 22(7), 1291-1297.

[DOI:10.1016/j.foodhyd.2007.06.010]

Sahnoun M., Bejar S., Daoud L., Ayadi L., Brini F. & Saibi W. (2017). Effect of *Agave Americana* L. on the human, and *Aspergillus oryzae* S2 α-amylase inhibitions. *Natural Product Research,* 755-758.

[DOI:10.1080/14786419.2017.1408094]

Salazar-Leyva J. A., Osuna-Ruizi I., Rodriguez-Tirado V. A., Zazueta-Patron I. E. & Brito-Rojas H. D. (2016). Optimization study of fructans extraction from *Agave tequilana* Weber azul variety. *Food Science and Technology Campinas,* 36(4), 631-637.

[DOI:10.1590/1678-457X.11216]

Sánchez-Bravo, P. Zapata, P. Martínez-Esplá, A. Carbonell-Barrachina, A. & Sendra, E. (2018). Antioxidant and anthocyanin content in fermented milks with sweet cherry is affected by the starter culture and the ripening stage of the cherry. *Beverages*, 4 (3), 57-69.

[DOI:10.3390/beverages4030057]

Sengul M., Erkaya T., Sengul M. & Yildiz H. (2012). The effect of adding sour cherry pulp into yoghurt on the physicochemical properties, phenolic content and antioxidant activity during storage. *International Journal of Dairy Technology,* 65(3), 429-436.

[DOI:10.1111/j.1471-0307.2012.00838.x]

Shokery E. S., El-Ziney M. G., Yossef A. H. & Mashaly R. I. (2017). Effect of green tea and Moringa leave extracts fortification on the physicochemical, rheological, sensory and antioxidant properties of set-type yoghurt. *Journal of Advances Dairy Research,* 5(179), 2-10.

[DOI:10.4172/2329-888X.1000179]

Shori A. B. & Baba A. S. (2013). Antioxidant activity and inhibition of key enzymes linked to type-2 diabetes and hypertension by *Azadirachta indica*-yogurt. *Journal of Saudi Chemical Society,* 17(3), 295-301.

[DOI:10.1016/j.jscs.2011.04.006]

Shori A. B. (2013). Nutritional and therapeutical values of chickpea water extract enriched yogurt made from cow and camel milk. *American Journal of Drug Discovery and Development,* 3(2), 47-59.

[DOI:10.3923/ajdd.2013.47.59]

Urias-Silvas J. E., Cani P. D., Delmee E., Neyrinck A. & Lopez M. G. (2008). Physiological effects of dietary fructans extracted from *Agave tequilana* Gto and *Dasylirion* spp. *British Journal of Nutrition,* 99, 254-261.

[DOI:10.1017/S0007114507795338]

Vasco C., Ruales J. & Kamal-Eldin A. (2008). Total phenolic compounds and antioxidant capacities of major fruits from Ecuador. *Food Chemistry,* 111(4), 816-823.

[DOI:10.1016/j.foodchem.2008.04.054]

Vital A. C. P., Goto P. A., Hanai L. N., Costa S. M. G., Filho B. A. A. & Verata C. (2015). Microbiological, functional and rheological properties of low fat yogurt supplemented with *Pleurotus ostreatus* aqueous extract. *LWT - Food Science and Technology,* 64, 1028-1035.

480 [DOI:10.1016/j.lwt.2015.07.003]

Yadav K., Bajaj R. K., Mandal S., Saha P. & Mann B. (2018). Evaluation of total phenol content and antioxidant properties of encapsulated grape seed extract in yoghurt. *International Journal of Dairy Technology,* 71(1), 96-104.

[DOI:10.1111/1471-0307.12464]

485 Zamora-Gasga V. M., Loarca-Pina G., Vazquez-Landaverde P. A., Ortiz-Basurto R. I., Tovar J. & Sayago-Ayerdi S. G. (2015). In vitro colonic fermentation of food ingredients isolated from *agave tequilana* weber var. azul applied on granola bars. *LWT - Food Science and Technology,* 60, 766-772.

[DOI:10.1016/j.lwt.2014.10.032]

490 Zare F., Boye J. I., Orsat V., Champagne C. & Simpson B. K. (2011). Microbial, physical and sensory properties of yogurt supplemented with lentil flour. *Food Research International,* 44, 2482–2488.

[DOI:10.1016/j.foodres.2011.01.002]

مطالعه اثر عصاره آبی *آگاو تکیلانا* بر خواص آنتی اکسیدانی، آب اندازی و خصوصیات حسی ماست پروبیوتیک

ملیکا فرزانه[1]، وجیهه فدائی [1*]، حسن گندمی نصرآبادی[2]

1 گروه علوم و صنایع غذایی، واحد شهرقدس، دانشگاه آزاد اسلامی، تهران، ایران.

2 گروه بهداشت و کنترل کیفی مواد غذایی، دانشکده دامپزشکی، دانشگاه تهران، تهران، ایران.

چکیده

زمینه مطالعه: علاقه رو به رشد مصرف کنندگان به غذای سالم، صنعت را تشویق کرده است تا محصولات غذایی را جستجو کند که اثر عملگرایی فراتر از ارزش غذایی دارند. ماست یکی از بهترین حامل ها برای مواد غذایی کاربردی از جمله پروبیوتیک ها و آنتی اکسیدان ها است. *آگاو تکیلانا* یک گیاه حاوی فیتوکمیکال های حاوی فلاونوئیدها است که فعالیت آنتی اکسیدانی نشان می دهد.

هدف: در این مطالعه، اثرات اضافه کردن عصاره آبی آگاو تکیلانا (AEAT) بر خواص آنتی اکسیدانی، آب اندازی و خصوصیات حسی ماست پروبیوتیک مورد بررسی قرار گرفت.

روش کار: محتوای فنلی کل نمونه‌های ماست به روش فولین سیوکالتیو اندازه‌گیری شد. فعالیت آنتی اکسیدانی نمونه های ماست با استفاده از روش DPPH تعیین شد. آب اندازی نمونه های ماست با استفاده از روش سانتریفیوژ اندازه گیری شد. آنالیز حسی با استفاده از آزمون هدونیک پنج نقطه ای انجام شد.

نتایج: محتوای فنلی به ترتیب 389/9، 629/2 و 905/6 میلی‌گرم اسید گالیک در کیلوگرم در غلظت‌های 0/5، 1 و 1/5 درصد عصاره بود. فعالیت آنتی اکسیدانی ماست با افزایش غلظت عصاره افزایش یافت، به طوری که نمونه های ماست سین بیوتیک حاوی غلظت های 0.5، 1 و 1.5 درصد AEAT به ترتیب 283، 480 و 617 mgBHT eq./kg فعالیت آنتی اکسیدانی را نشان دادند. نمونه های ماست سین بیوتیک در مقایسه با نمونه های ساده و پروبیوتیک آب اندازی بالاتری نشان دادند. اگرچه ویژگی‌های حسی نمونه‌های ماست سین بیوتیک کمتر از تیمارهای ساده و پروبیوتیک بود، اما امتیاز آن‌ها همچنان بالاتر از حد قابل قبول بود.

نتیجه گیری نهایی: از آنجایی که نتایج این مطالعه نشان دهنده بهبود خواص آنتی اکسیدانی ماست غنی شده با عصاره آبی آگاو است، کاربرد بالقوه آن به عنوان یک فرمولاسیون غذایی عملگرا توصیه می شود.

واژه های کلیدی: ماست سین بیوتیک، عصاره *آگاو تکیلانا*، فعالیت آنتی اکسیدانی، فنل کل، آب اندازی