Article

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Formulation of goat's milk yogurt with fig powder: Aromatic profile, physicochemical and microbiological characteristics

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Abstract

Fig (*Ficus carica* L.) is an excellent source of sugars, dietary fibers, minerals, vitamins, organic acids and phytochemicals. The aim of the present work was to investigate the effect of fig powder supplement, as a natural sweetener and flavoring agent, on the physicochemical, microbiological and sensory characteristics of goat's milk yogurt. It aimed also to determine antioxidant capacity and volatile profile using gas chromatography/mass spectrometry (GC/MS) analysis. Pyrolysis-GC/MS (Py-GC/MS) was also used for the characterization of fig powder. Fig powder exhibited an important antioxidant activity against DPPH$^{\cdot}$ Radical ($IC_{50} = 1.92 \pm 0.05$ mg per mL). Volatile compounds, from several classes (acids, alcohols, aldehydes, esters, triterpenoids and others) were identified in fig powder. Py-GC/MS data revealed that degradation of fig powder macromolecules leaded to the formation of several aromatic and volatile compounds such as fatty acids, ketones, aromatic phenols, lactones among others. The addition of fig powder increased significantly ($p < 0.05$) the titrable acidity, the total solids, the carbohydrate content, and the total lactic acid bacteria count of yogurts. Likewise, fig powder supplement improved yogurt taste, texture and aroma and covered the unpleasant flavor of goat's milk. Thus, fig powder is a natural sweetener and flavoring agent that can be used to formulate a new stirred goat's yogurt of good quality.

Keywords

Fig powder, flavoring agent, volatile compounds, goat's milk, stirred yogurt

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INTRODUCTION

The relationship between food and health becomes increasingly significant, as consumers now demand healthy, tasty, and natural functional foods (Abbasi et al., 2013). Figs, an important food in the Mediterranean diet, are rich in fibers, minerals, sugars, organic acids, phenolics with antioxidant capacity and volatile compounds that provide a pleasant characteristic aroma (Slatnar et al., 2011; Solomon et al., 2006).

One of the essential parameters of fruit quality is the aroma, which is determined by the volatile components. The aromatic compound profile has a great influence on organoleptic characteristics and therefore on consumer acceptance. Volatiles can be derived from amino acids, fatty acids and carbohydrate compounds and belong to a wide variety of chemical classes, mainly

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aldehydes, terpenoids, esters, alcohols, acids, ketones, and other compounds (Ficsor et al., 2013; Pereira et al., 2020; Russo et al., 2017).

The major aldehydes and alcohols in figs are hexanal, nonanal, acetaldehyde, decanal, methanol, ethanol and 2,3-butanediol (Gozlekci et al., 2011; Grison-Pigé et al., 2002; Oliveira et al., 2010a, 2010b; Trad et al., 2012). Butyl acetate, isoamyl acetate, hexyl acetate, methyl salicylate, ethyl salicylate are the main esters found in figs (Oliveira et al., 2010a; Trad et al., 2012). Fig also contains sterols and terpenoids: sitosterol, stigmasterol, linalool, limonene, β-Caryophyllene, α-Cubebene, β-Selinene, Germacrene D, menthol, α-Amyrin and lupeol (Gibernau et al., 1997 Jeong and Lachance,2001; Li et al., 2011; Ribechini et al., 2011). In addition, compounds such as furfural, benzaldehyde, phenol, among others, have also shown a remarkable influence on the aroma of fig fruit (Pereira et al., 2020).

Drying decreases considerably the water activity of the material, reduces microbiological activity and minimizes physical and chemical changes during its storage period. The effect of drying on the aromatic profile of figs was previously investigated (Mujić et al., 2014; Russo et al., 2017).

The particular interest in goat's milk is prompted by its indisputable dietetic properties and its higher nutritive value compared to cow's milk. Goat's milk is reported to have higher digestibility and lower allergenic properties when compared to cow's milk, as well as a higher content of zinc, iron and magnesium and antibacterial characteristics (Boycheva et al., 2011; Ranadheera et al., 2012).

However, goat's milk imparts a characteristic unpleasant flavor derived from caprylic, capric, and caproic acids present in this milk and dairy products, restricting its acceptance by many consumers and the development of goat dairy products (Ranadheera et al., 2018). In our study, we tried to mask this unpleasant flavor by adding fig powder, which has a pleasant aroma, to the goat's milk yogurt.

First, we focus our research on the physicochemical characteristics and the aromatic constituents of fig powder. To our knowledge, there are no papers dealing with the volatile compounds in fig powder. Then we tried to formulate a new stirred goat's milk yogurt using fig powder as a natural sweetener and flavoring agent and to determine its physicochemical, microbiological and sensory characteristics. As far as we know, fig powder has not been used in dairy products before.

MATERIALS AND METHODS

Sample preparation

Sun dried figs of the 'Bakkor Khal' variety [second production] (DM = 78.77%) were cut in small pieces of about one centimeter diameter and dried in the oven for 14 hours at 60 °C. The dried figs were powdered using a coffee grinder, sifted and stored in a glass container.

Drying kinetics

Drying kinetics of the dark figs was evaluated by plotting a curve of moisture ratio as a function of drying time. Weight change was recorded using a digital balance (Kern, accuracy of ±0.001 g) at an hourly interval during drying. The equilibrium moisture content was calculated as described by Babalis and Belessiotis (2004).

Extraction of active compounds

Active compounds were extracted by SSDM (Sea-Sand-Disruption Method) according to the method described by Teixeira et al. (2006). Compounds were eluted with ethyl acetate.

Antioxidant activity

The antioxidant activity of the ethyl acetate extract of fig powder was determined by the DPPH· method (2,2′-diphenyl-1-picrylhydrazyl) as described by Mahmoudi et al. (2018). The result was expressed as IC_{50} (mg per mL), which is the amount of sample needed to decrease by 50% the absorbance of DPPH. IC_{50} value was calculated by plotting inhibition percentages against concentrations of the sample.

GC/MS conditions

Fifty μL of fig's ethyl acetate extract were evaporated to dryness under a stream of nitrogen. The extract was re-dissolved in 50 μL of *n*-hexane and derivatised with 50 μL of BSTFA *N*,*O*-Bis(trimethylsilyl)trifluoroacetamide (containing 1% Trimethylchlorosilane, Trimethylsilyl chloride, TMCS) in a microwave oven (700 W, 30 seconds). BSTFA excess was removed under a light stream of nitrogen and the derivatized extract was dissolved in 50 μL of *n*-hexane and analyzed by GC/MS. A Shimadzu GC2010 gas chromatographer coupled to a GCMS-QP2010 Ultra Mass Spectrometer was used. The gas chromatograph was equipped with a Phenomenex Zebron column ZB-5HT (15 m length, 0.25 mm I.D., 0.10 μm film thickness). The sample (1 μL) was injected in splitless mode for a sampling time of 1 minute with the injector temperature set at 200 °C and a helium column flow of 1.2 mL.min^{-1}. The mass spectrometer was operated in EI mode (70 eV). Ion source temperature was set at 240 °C and interface temperature was maintained at 280 °C. The GC oven temperature program was set at 35 °C for 5 min, then ramped to 220 °C at 2 °C/min, followed by a 30 min isothermal period. The mass spectrometer was scanned from 40 to 850 m/z. Peak assignment was done using the NIST11 and Wiley7 mass spectral libraries, through AMDIS software.

Py-GC/MS conditions

A system with a Frontier Lab PY-3030D double-shot pyrolyzer was used, with an interface temperature of 280 °C. The pyrolyzer was coupled to a Shimadzu GC2010 gas chromatographer, also coupled to a Shimadzu GCMS-QP2010 Plus mass spectrometer. A capillary column Phenomenex Zebron ZB-5HT (30 m length, 0.25 mm internal diameter, 0.50 µm film thickness) was used for separation, with helium as carrier gas, adjusted to a flow rate of 2.2 mL.min-1. The splitless injector operated at a temperature of 250 °C. GC temperature program was as follows: 40 °C during 5 min, ramp until 300 °C at 5 °C min-1 and then an isothermal period of 3 min. Source temperature was placed at 240 °C, and the interface temperature was maintained at 280 °C. Samples of approximately 0.5–1.0 mg of fig powder were analyzed by Py-GC/MS. Samples were derivatized with 3 µL of Trimethylphenylammonium hydroxide, TMAH (25% in methanol) in a 50 µL Eco-cup capsule and placed in the double shot pyrolyzer using an Eco-stick. The sample was pyrolyzed using a single-shot method at 500 °C. The mass spectrometer was programmed to acquire data between 40 and 850 m/z. Compound identification was performed using AMDIS software integrated with NIST11 and Wiley7 databases.

Yogurt preparation

Fresh goat's milk (mixed race: Arabia-Alpine) from the department of M'sila (Steppe of Algeria) was pasteurized (95°C/5 min), cooled to 45°C, and inoculated with 0.03% starter culture containing *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* (Thermophilic yogurt culture YOFLEX®, Denmark). The mixture was incubated for 3 hours at 45 °C, cooled to 20 °C, stirred and stored in a refrigerator at 4 °C. Four lots: one control and three experimental were prepared. For the experimental lots, 8, 10 and 12 g of fig powder were added to the milk before coagulation.

Physicochemical analyses

The following parameters were determined in goat's milk and yogurts: titratable acidity using 0.1 N sodium hydroxide (AOAC, 947.05), total solids (AOAC 925.23), total ashes (AOAC 945.46), fats (%) by Gerber method (Sboui et al., 2016), carbohydrates (Dubois et al., 1956) and proteins by Kjeldahl (AOAC, 920.105). Physicochemical characteristics of fig powder were analyzed according to Mahmoudi et al. (2018).

Microbiological analyses

Total aerobic mesophilic bacteria on Plate Count Agar at 30 °C; total and fecal coliforms on Deoxycholate Agar at 30 and 40 °C respectively; *Staphylococcus aureus* on Beard Parker Agar at 37 °C; yeast and molds on Sabouraud Agar; *Lactobacillus delbrueckii* subsp. *bulgaricus* on MRS Agar and *Streptococcus thermophilus* on M17 Agar have been searched in milk and yogurt (JORA, 2004).

Sensory analysis

Twenty-five panelists (15 female and 10 male) were selected for the sensory test of plain and stirred fig powder goat's milk yogurts, twenty-four hours after production. The age of the panelists ranged from 21 to 40 years old. The panelists were regular consumers of yogurt, not allergic to milk, and willing to participate. The yogurt samples were evaluated for taste, aroma, texture, and overall acceptability using a 9-point hedonic scale ranging from 9 (Liked very much) to 1 (Disliked extremely) (Ranadheera et al., 2012).

Statistical analysis

Results were shown as mean ± SEM. Statistical significance at $p < 0.05$ was determined by ANOVA (one-way) followed by Tukey's multiple comparison tests using GraphPad Prism 6 statistics program.

RESULTS AND DISCUSSION

Drying kinetics

Moisture ratio versus drying time obtained for the Bakkor Khal figs at 60 °C is represented in Figure 1. The drying process consists of decreasing the moisture content of figs from 21.23 ± 0.52 to 8.71 ± 0.45% wb (wet base), which took 14 hours. As compared to Khapre et al. (2015) data, drying process, at the same temperature, took 20 to 24 hours to reduce the moisture content from 75.3 to 10.43%.

An important decrease of moisture ratio values was observed in the first six hours of drying process. After this period, changes in moisture ratio values became less relevant. Babalis and Belessiotis (2004) reported that the convective drying of figs took place predominantly in the falling rate period for the temperature values investigated (about 10-15 h).

In fruits such as figs, rich in sugars, smaller variations in moisture ratios after 6 hours can be explained according to Amellal and Benamara, (2008); Drouzas

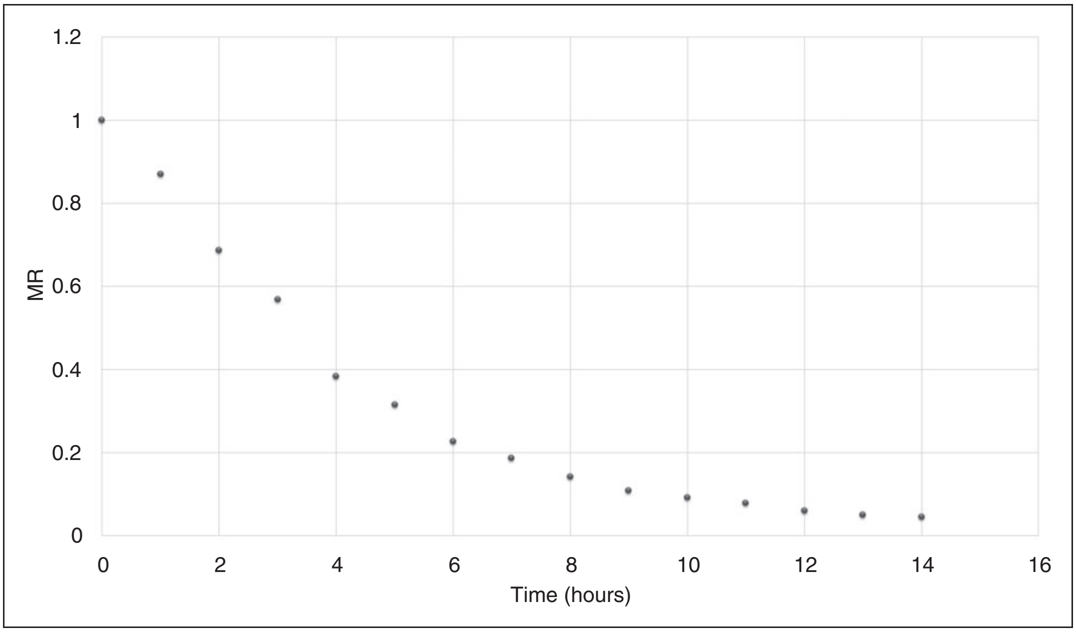

Figure 1. Drying curve of figs (Bakkor Khal), moisture ratio (MR) versus drying time.

Table 1. Physicochemical characteristics and antioxidant capacity of fig powder.

Parameter	Moisture (%)	Ashes (%)	Carbohydrates (g per 100g)	Proteins (%)	Antioxidant capacity IC_{50} (mg per mL)
Fig powder	8.71 ± 0.45	2.78 ± 0.12	71.06 ± 0.58	6.05 ± 0.22	1.92 ± 0.05

Data was represented as mean $\pm$ SEM of three measurements. IC_{50}: the amount of sample needed to decrease by 50% the absorbance of DPPH.

et al. (1999) by the high sugar content that causes shrinkage and collapse of the gel structure during air-drying, resulting in a low transport rate of water.

Physicochemical characteristics and antioxidant capacity of fig powder

Drying is an important step to reduce moisture content of figs down to 8.71% wb, which simplifies their grinding and the production of fig powder (Table 1). For the production of fruit powder, a lower moisture content (2 to 8%) eases the grinding process (Karam et al., 2016).

The ash content is three times higher in fig powder than in the pulp of fresh fig of the same variety (0.84% wb) (Mahmoudi et al., 2018). This high ash content may be explained by the reduction of moisture content in fig powder. In addition, carbohydrate and protein contents in our sample are higher than those reported in dried figs (66.16 and 3.14%) and in fig powder (61.52 and 5.26%) (Barolo et al., 2014; Khapre et al., 2015).

The antioxidant activity was higher for fig powder (Table 1) than for peel and pulp of fig varieties Bakkor Khal (2.48 and 15.87 mg per mL) and Branca Tradicional (3.45 and 8.11 mg per mL) fresh fruits (Mahmoudi et al., 2018; Oliveira et al., 2009). According to Karam et al. (2016), antioxidant capacity might enhance after drying due to polyphenols with intermediate oxidation state (which usually exhibit a higher scavenging activity than non-oxidized polyphenols) and to the formation of Maillard reaction products acting as pro- or antioxidants.

Fig powder is commercialized in many countries around the world and used in baking, snacking, sauces and pet food, as binding and bulking agent, source of fiber, nutrients and antioxidants, natural sweetener and flavoring agent.

GC/MS analysis

Aroma is one of the essential factors for the evaluation of fruit quality. In fact, the aroma of fruits is the result of a complex mixture of esters, alcohols, aldehydes, terpenoid compounds among others, at low concentrations (Oliveira et al., 2010b).

In our investigation, forty-two volatile compounds, belonging to different chemical classes, were identified by GC/MS in fig powder of Bakkor Khal variety (Table 2, Figure 2). The major compounds belong to the fatty acids (56.7%) triterpenoid sterols and vitamins (32.6%), esters and ethers (5.2%) and monoacylglycerol (3.1%) classes. Among these compounds, saturated, mono and poly-unsaturated fatty acids were determined in our sample. From these compounds, the major ones were palmitic, linoleic, oleic, linolenic, stearic and myristic acids, which were previously identified in dried figs (Jeong and Lachance, 2001). According to Pande and Akoh (2010), the fatty acid profile of raw ripe figs is dominated by linoleic (28.2%), palmitic (27.5%), linolenic (20.7%) and oleic (20.2%) acids. In contrast, Jeong and Lachance (2001) found that linolenic acid was the most predominant fatty acid (53.1%) in dried fig fruit. Linoleic acid, an essential nutrient for humans, is found at high levels in the fig skin (Guvenc et al., 2009). Oleic acid is reported to have plasma cholesterol-lowering activity, while linoleic and linolenic acid can convert to hormone-like substances called eicosanoids, which affect physiological reactions ranging from blood clotting to immune response (Jeong and Lachance, 2001). Phenolic acids, vanillic acid and protocatechuic acid contribute also to the fig powder aroma.

To our knowledge, the alcohol, 1-hexadecanol was reported for the first time in figs. 2,4-decadienal was the only aldehyde found in fig powder. This compound was previously identified in fresh Tunisian figs (Trad et al., 2012). In fact, in the production of raisins, 2,4-decadienal was reported to derive from unsaturated fatty acid oxidative degradation and has a high probability of contributing to the total aroma/flavor of raisins, because of its significant odor threshold (Mujić et al., 2014).

GC/MS analysis revealed the presence of glycosides (D-(-)-fructofuranose, D-(-)-ribofuranose and glucopyranose). Glucose and fructose are the dominant sugars in fig fruits (Aljane and Ferchichi, 2009). The most important chemical reactions affecting sugars during drying are acid hydrolysis, Maillard reactions, and caramelization (Özel and Gögüs, 2010). As a result of Maillard reaction, only one lactone (D-arabinonic acid, γ-lactone) was found in fig powder. This compound was previously identified in glucose and glucose/glycine Maillard model systems (Haffenden and Yaylayan, 2008).

The esters, the most important volatiles in ripe fig fruits, are major contributors to fruit aroma. Volatile esters are generated by esterification of alcohols and acyl-CoAs derived from both fatty acid and amino acid metabolism in a reaction catalyzed by the enzyme alcohol-o-acyltransferase (Trad et al., 2012). Hexadecanoic acid methyl ester, Hexadecanoic acid ethyl ester, linoleic acid methyl ester, linolenic acid methyl ester, oleic acid methyl ester and octadecanoic acid methyl ester, were identified in fig powder.

Triterpenoids are widely distributed in edible and medicinal plants and are an integral part of the human diet. As an important group of phytochemicals that exhibit numerous biological effects and display various pharmacological activities, triterpenoids are being evaluated for use in new functional foods, drugs, cosmetics and healthcare products (Szakiel et al., 2012). Fig powder is a rich source of triterpenoids, especially lupeol acetate, α-amyrin and β-amyrin. These components were previously identified in Italian and Spanish dried figs (Ribechini et al., 2011). According to Gallo and Sarachine (2009), lupeol has the ability of interacting with multiple molecular targets, affecting and modulating the inflammation process, carcinogenesis and cellular stress response. α- and β-amyrin have been shown to exhibit various pharmacological activities in *vitro* and in *vivo* conditions against various health-related conditions, including conditions such as inflammation, microbial, fungal and viral infections and cancer (Hernández Vázquez et al., 2012). To our knowledge, the triterpenoids norolean-12-ene and noruns-12-ene and the sterol lanosterol acetate were identified in figs for the first time. Lanosterol has been identified from several plant extracts including the leaf and the latex of *Ficus carica*, *Arabidopsis thaliana* and the latex of *Euphorbia peplus* (Giner et al., 2000; Ivanov et al., 2018, Ohyama et al., 2009; Oliveira et al., 2010c). According to Suzuki et al. (2006) plants also have the ability to synthesize lanosterol directly from 2,3-oxidosqualene, which may lead to a new pathway to plant sterols.

An isoprenoid ketone, 2-pentadecanone, 6,10,14-trimethyl- was reported in our sample. This volatile was previously identified in *Ficus carica* fruit and in many *Ficus* species and described as a biomarker of their essential oils (Adebayo et al., 2015; Soni et al., 2014).

Py-GC/MS analysis

Figs, like other fruits, are complex plant materials containing small organic molecules (acyl-lipids, waxes, phytosterols, carotenoids and triterpenes) and biopolymers. The biopolymers consist mainly of cellulose, hemicellulose, pectins, lignin and polyphenols (Ribechini et al., 2011).

The main pyrolysis products present in fig powder were identified by Py-GC/MS and listed in Table 3. Figure 3 shows the Py-GC/MS chromatogram of Bakkor Khal fig powder sample. The pyrolysis products belong to several chemical groups such as fatty acids and vitamins (45.9%), ketones (18.1%), aromatic phenols (17.9%), organic acids (10.6%), and others. The identified pyrolysis products can be originated

Table 2. Compounds identified by GC/MS in ethyl acetate extract of fig powder (Bakkor Khal).

Name	RT (min.)	Amount (%)[a]	Odor description[b]
Fatty acids			
Caprylic acid, TMS	23.14	0.010	fatty waxy rancid oily vegetable cheesy
Pelargonic acid, TMS	28.94	0.040	Sweet, fruity, pear-like, waxy
Capric acid, TMS	34.65	0.010	oily fruity floral
Lauric acid, TMS	45.26	0.030	mild fatty coconut bay oil
Myristic acid, TMS	55.02	0.090	waxy fatty soapy coconut
Pentadecylic acid, TMS	59.61	0.070	slightly waxy fatty
Palmitoleic acid, TMS	62.59	0.060	/
Palmitelaidic acid, TMS	62.83	0.040	/
Palmitic acid, TMS	64.10	2.510	/
Linoleic acid, TMS	70.64	0.720	/
Linolenic acid, TMS	70.92	0.600	/
Oleic acid, TMS	70.98	0.640	/
trans-13-Octadecenoic acid, TMS	71.28	0.100	/
Stearic acid, TMS	72.31	0.160	/
Sugars and lactones			
D-Arabinonic acid, γ-lactone, tri-TMS	44.83	0.010	Maillard reaction
D-(-)-Fructofuranose, penta TMS	54.67	0.120	/
D-(-)-Ribofuranose, tetra TMS	55.78	0.020	/
D-Glucopyranose, penta-TMS	59.28	0.020	/
Phenolic acids			
Vanillic acid, di-TMS	51.03	0.010	sweet creamy powdery vanilla bean
Protocatechuic acid, TMS	54.11	0.010	mild phenolic balsamic
Isoprenoid ketone			
2-Pentadecanone, 61,014-trimethyl-	54.21	0.010	oily herbal jasmin celery woody
Esters and ethers			
Palmitic acid, methyl ester	58.24	0.090	oily waxy fatty orris
Palmitic acid, ethyl ester	61.39	0.090	mild waxy fruity creamy milky balsam
Linoleic acid, methyl ester	65.34	0.110	oily fatty woody
Linolenic acid, methyl ester	65.57	0.100	Bland
Oleic acid, methyl ester	65.70	0.040	fatty waxy
Stearic acid, methyl ester	67.12	0.010	oily waxy
Caprylic ether	59.93	0.030	/
Alcohol and aldehyde			
1-Hexadecanol, O-TMS	60.29	0.010	waxy clean greasy floral oily
2,4-Decadienal	24.40	0.004	orange sweet fresh citrus fatty green
Monoacylglycerols			
1-Monolaurin, di-TMS	71.67	0.010	/
2-Monopalmitin, di-TMS	85.21	0.030	/
1-Monopalmitin, di-TMS	86.23	0.130	/
2-Monostearin, di-TMS	91.82	0.030	/
1-Monostearin, di-TMS	92.85	0.080	/
Triterpenoids sterols and vitamins			
γ-Tocopherol, TMS	98.37	0.150	/
Norolean-12-ene	107.97	0.010	/
Noruns-12-ene	108.90	0.030	/
β-Amyrin	116.10	0.780	/
α-Amyrin	119.04	0.550	/
Lupeol acetate	120.26	0.960	/
Lanosterol acetate	122.81	0.440	/

TMS: trimethylsilyl derivative; RT: retention time; /: not found.
[a]Amounts refer to the area of the component (ions count) relative to the total ion count for the entire chromatogram, expressed as a percentage.
[b]www.thegoodscentscompany.com.

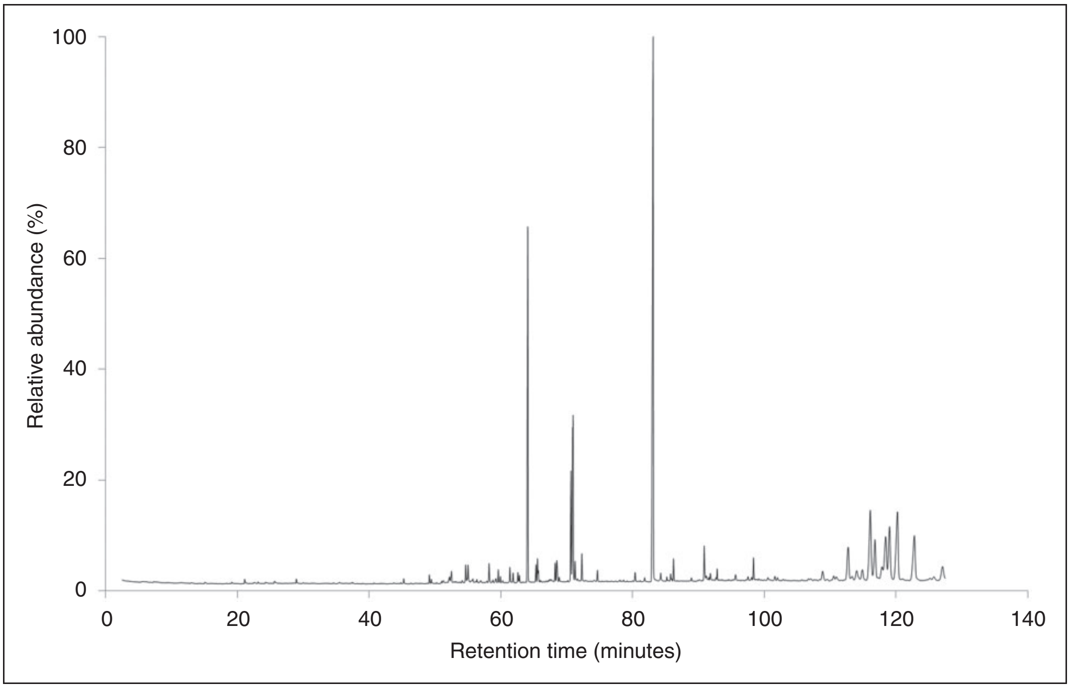

Figure 2. GC/MS chromatogram of fig powder extract of the variety Bakkor Khal.

from polymerized macromolecules such as proteins, lipids, cellulose and lignin.

Fatty acids, the major components of fig powder, are distributed in 44% polyunsaturated (C18), 41.1% saturated (C16 to C28) and 14.9% monounsaturated (C16, C18 and C20) fatty acids. Among the identified fatty acids in fig powder by Py-GC/MS, the major one is palmitic acid. This analysis revealed the presence of one monoterpene (limonene) and three aldehydes, in which p-Cresol methyl ether is the most abundant. Limonene was previously identified in figs by other researchers (Oliveira et al., 2010a; Pereira et al., 2020).

The aromatic phenol class is dominated by o-Guaiacol, which is in agreement with Ribechini et al. (2011). This compound is derived from lignin through the shikimic pathway and has a comparable antioxidant activity to that of currently used commercial antioxidants (Azadfar et al., 2015). Lignin is a complex phenolic polymer formed from three alcohol monomers (p-coumarol, coniferol and sinapol). Coniferol was detected in our simple. The most abundant acid in fig powder is levulinic acid, which is derived from degradation of cellulose. Succinic acid was previously identified in fig fruit (Pereira et al., 2017). These acids can be used as precursors for many products of industrial importance.

Lactones constitute 3% of the identified compounds in fig powder. According to Osorio et al. (2010), lactones are a major group of the fatty acid-derived flavor compounds. Lactones are organoleptically important and due to their low odor threshold, they have a high flavor value in fruits and food industry. These compounds are cyclic esters of primarily γ- and δ-hydroxy acids, being generally formed by successive β-oxidations of saturated and unsaturated hydroxyl acids or their lipid precursors until this process results in a hydroxylated carbon at the C4 or C5 position.

From the ketone class, the most abundant identified compound in fig powder is 2-hydroxy-3-methylcyclopent-2-enone (19.7%). In order to calculate the carbohydrate content using the Py-GC/MS, this compound was chosen as a marker compound for carbohydrates in microalgae (Biller and Ross, 2014). These authors have also chosen indole as a marker for proteins. Indoles result from the degradation by temperature of tryptophan (2-amino-3-(3′-indolyl) propionic acid).

Physicochemical characteristics of goat's milk and yogurts

The effect of fig powder supplements on the physicochemical characteristics of goat's milk yogurt was investigated. From data recorded in Table 4, it appears clearly that fig powder supplements increased significantly ($p < 0.05$) the titratable acidity, the total solids and the carbohydrates content of yogurt with fig, when compared to plain yogurt. However, this supplementation did not affect the ash, protein and fat content in goat's milk yogurts.

The total solids, protein, and fat contents (12.05, 3.75 and 4.20%, respectively) of goat's milk registered

Table 3. Compounds identified by Py-GC/MS in fig powder (Bakkor Khal).

Name	RT (min.)	Amount[a] (%)
Lactones		
Protoanemonin	9.07	0.037
γ-Butyrolactone	10.59	0.106
γ-Crotonolactone	10.72	0.033
β-Angelica lactone	11.97	0.027
α-Methyl-γ-crotonolactone	13.75	0.028
Organic acids		
Pyruvic acid, ME	2.60	0.089
Propyl lactate	12.58	0.059
Furoic acid, ME	13.70	0.065
Levulinic acid, ME	14.24	0.212
Fumaric acid, di-ME	15.65	0.048
Succinic acid, di-ME	16.07	0.167
Glutaric acid, di-ME	19.71	0.054
m-Anisic acid, ME	25.86	0.049
Vanillic acid, ME	30.55	0.022
Azelaic acid, di-ME	31.14	0.023
Homoveratric acid, ME	33.10	0.020
Ketones		
2-Methylpentan-3-one	5.01	0.027
Acetoxyacetone	8.40	0.118
2-Methyl-2-cyclopenten-1-one	10.29	0.099
2-Acetylfuran	10.58	0.027
2-Hydroxy-2-cyclopenten-1-one	11.31	0.163
2,5-Hexanedione	11.52	0.035
3-Methyl-2-cyclopenten-1-one	13.16	0.100
3,4-Dimethyl-2-cyclopenten-1-one	14.38	0.025
2-Hydroxy-3-methylcyclopent-2-enone	15.81	0.272
5-Hydroxy-2-heptanone	16.23	0.102
2,5-Dimethyl-4-hydroxy-3(2H)-furanone	17.13	0.042
2,3,4-Trimethyl-2-cyclopenten-1-one	17.14	0.035
3-Ethyl-2-hydroxy-2-cyclopenten-1-one	17.65	0.147
2-Ethyl-3-methoxy-2-cyclopenten-1-one	18.44	0.083
Acetovanillone	29.81	0.026
2-Propiovanillone	30.90	0.028
Acetoveratrone	31.65	0.055
Alcohols		
Furfuryl alcohol	7.56	0.080
Coniferol	35.70	0.021
Aldehydes		
5-Methylfurfural	13.11	0.029
p-Cresol methyl ether	15.51	0.046
3-Methoxybenzaldehyde	21.75	0.031
Monoterpenes		
Limonene	15.85	0.029
Aromatic phenols		
o-Cresol	17.00	0.054
p-Cresol	17.75	0.053
o-Guaiacol	18.11	0.437
2,6-Dimethylphenol	18.76	0.038
o-Dimethoxybenzene	20.03	0.120
3,4-Dimethylphenol	20.18	0.037
3,5-Dimethylphenol	20.22	0.037
p-Dimethoxybenzene	20.60	0.044
3,4-Dimethoxytoluene	20.96	0.042

(continued)

Table 3. Continued.

Name	RT (min.)	Amount[a] (%)
4-Methylguaiacol	21.11	0.065
4-Methoxy-3-methylphenol	21.34	0.062
5-Methylguaiacol	21.56	0.100
2,3-Dimethoxytoluene	22.93	0.065
2,5-Dimethoxytoluene	23.27	0.047
Syringol	25.77	0.031
1,2,4-Trimethoxybenzene	26.68	0.085
Isoeugenol	28.83	0.057
N-containing compounds		
Indole	24.64	0.020
Proline, 5-oxo-, ME	26.88	0.089
Fatty acids and vitamins		
Palmitoleic acid, ME	39.03	0.021
Palmitic acid, ME	39.44	0.931
Palmitic acid	40.10	0.091
Margaric acid, ME	41.39	0.015
Linoleic acid, ME	42.72	0.433
Oleic acid, ME	42.83	0.426
Linolenic acid, ME	42.86	0.330
Octadecenoic acid isomer, ME	42.92	0.053
Stearic acid, ME	43.27	0.212
Octadecadienoic acid isomer 1, ME	43.62	0.246
Octadecadienoic acid isomer 2, ME	43.76	0.484
Octadecadienoic acid isomer 3, ME	44.37	0.051
Gondoic acid, ME	46.38	0.024
Arachidic acid, ME	46.79	0.074
Behenic acid, ME	50.04	0.051
Tricosylic acid, ME	51.57	0.005
Lignoceric acid, ME	53.05	0.025
Cerotic acid, ME	55.85	0.019
γ-Tocopherol	57.70	0.003
Montanic acid, ME	58.64	0.020

ME: Methyl ester derivative; RT: retention time.
[a]Amounts refer to the area of the component (ions count) relative to the total ion count for the entire chromatogram, expressed as a percentage.

in our study are higher than the values reported by Silva et al. (2017) (11.25, 3.1 and 3%, respectively).

The incorporation of fig powder in yogurt increased its acidity. Silva et al. (2017) had observed this fact previously in the probiotic goat's milk supplemented with Isabel grapes. The authors related this with the increased production of lactic acid and the natural high acidity of Isabel grape preparations.

For probiotic goat's milk yogurts with fruit juice, Ranadheera et al. (2012) reported that due to the higher acidity of the fruit juice, a decrease in the pH of the yogurt base was noted when stirred fruit yogurts were produced. In contrast, Feng et al. (2018) reported the non-significant differences in the acidity and pH values of all goat's milk yogurts with jujube pulp and the plain yogurt, which could be associated with the lower production of lactic acid from the growth of lactic acid bacteria. High quality protein, such as that found in yogurt, is important for bone health and building/maintaining muscle mass (Freitas, 2017).

Microbiological characteristics of yogurts

Microbiological characteristics' data indicated that pasteurized goat's milk and yogurts had a satisfactory quality. The total and fecal coliforms and Staphylococci were absent whereas, mold and yeast counts were <3 CFU per g, which mean that the yogurts with fig powder were safe for human consumption.

The *S. thermophilus* counts (1.31 to 10.03 10^7 CFU per g) were higher than those obtained for *L. bulgaricus* (0.5 to 5.61 10^7 CFU per g) for all the yogurt preparations (Figure 4), which is in agreement with several studies (Birollo et al., 2000; Feng et al., 2018; Silva et al., 2017).

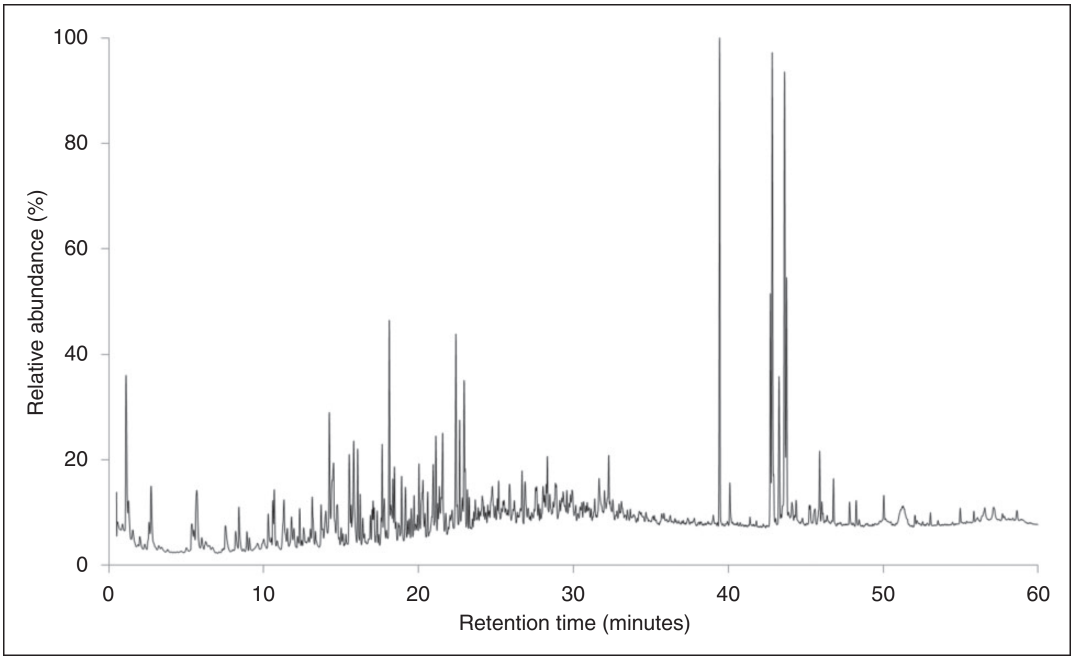

Figure 3. Py-GC/MS pyrogram of Bakkor Khal fig powder.

Table 4. Physicochemical characteristics of goat's milk and yogurts.

Samples	Acidity (g lactic acid per 100 g)	Total solids (%)	Ashes (%)	Carbohydrates (%)	Proteins (%)	Fats (%)
Goat's milk	0.16 ± 0.04^a	12.05 ± 0.14^a	0.848 ± 0.069^a	3.98 ± 0.078^a	3.75 ± 0.18^a	4.20 ± 0.07^a
YC_0	0.78 ± 0.04^b	11.34 ± 0.15^b	0.693 ± 0.014^a	3.87 ± 0.247^a	2.26 ± 0.22^a	3.40 ± 0.06^b
YC_1	0.96 ± 0.08^c	17.01 ± 0.30^c	0.806 ± 0.031^a	10.45 ± 0.217^b	2.31 ± 0.20^a	3.50 ± 0.20^b
YC_2	1.05 ± 0.04^{cd}	18.37 ± 0.11^d	0.773 ± 0.027^a	11.49 ± 0.244^b	2.12 ± 0.57^a	3.45 ± 0.10^b
YC_3	1.15 ± 0.07^d	23.31 ± 0.09^e	0.748 ± 0.047^a	12.69 ± 0.295^c	2.10 ± 0.32^a	3.50 ± 0.08^b

YC0: plain yogurt, YC1: yogurt with 8% fig powder, YC2: yogurt with 10% fig powder, YC3: yogurt with 12% fig powder. Data were represented as mean ± SEM of three measurements. Data in the same column with different letters indicated significant differences at $p < 0.05$ by mean of the Tukey's test.

It can be seen from the viable count of lactic acid bacteria in yogurts (Figure 4) that fig powder supplement had a positive effect on the growth of *S. thermophilus* ($p < 0.05$). There are no significant differences in the *L. bulgaricus* count between yogurts with 0, 8 and 10% of fig powder addition. The sum of lactic acid bacteria in yogurts with fig powder is higher than in plain yogurt and it increased gradually with the increasing of fig powder supplement ($p < 0.05$ for YC2 and YC3). Similar results were reported for goat's milk yogurt supplemented with aronia or blueberry juice (Boycheva et al., 2011). Those authors explained that this was due to the presence of biologically active substances (vitamins, amino acids etc.) in natural aronia and blueberry juices, which stimulated the development of lactic acid bacteria.

In disagreement with our results, Feng et al. (2018) had registered a decrease in the *L. bulgaricus* and *S. thermophilus* colonies with the increase of the concentration of jujube pulp, which was explained by the natural acidity and/or a lot of polyphenols in jujube pulp inhibiting the growth of lactic acid bacteria.

Sensory analysis

The scores shown in Table 5 revealed that the fig powder supplement influenced positively the sensory characteristics of goat's milk yogurts (taste, aroma,

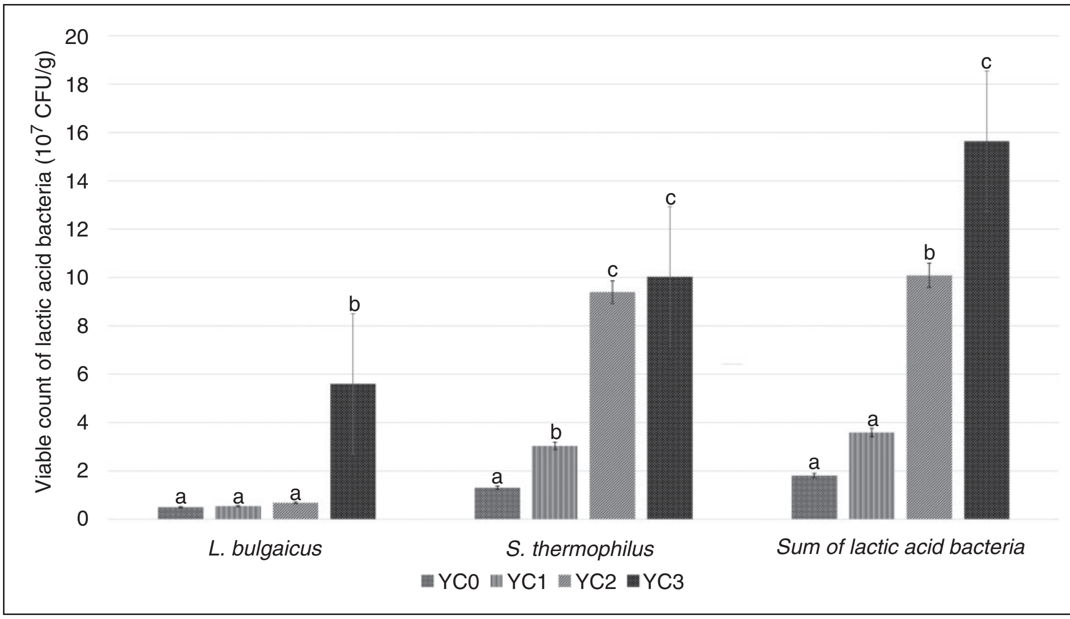

Figure 4. Viability of lactic acid bacteria in goat's milk yogurts containing fig powder.
YC0: plain yogurt, YC1: yogurt with 8% fig powder, YC2: yogurt with 10% fig powder, YC3: yogurt with 12% fig powder. Data for the same lactic acid bacteria type with different letters indicated significant differences at $p < 0.05$ by mean of the Tukey's test.

Table 5. Sensory quality and acceptability of goat's milk yogurts.

Characteristics Yogurt types	Taste	Aroma	Texture	Overall acceptability
YC0	2.25 ± 0.60^{a}	2.40 ± 0.56^{a}	5.00 ± 0.60^{a}	2.30 ± 0.49^{a}
YC1	4.40 ± 0.90^{b}	3.40 ± 0.52^{b}	5.60 ± 0.74^{ab}	5.05 ± 0.97^{b}
YC2	4.60 ± 0.76^{b}	5.50 ± 0.85^{c}	6.15 ± 0.86^{b}	5.80 ± 0.90^{b}
YC3	6.80 ± 0.84^{c}	6.20 ± 0.96^{c}	7.00 ± 0.90^{c}	6.95 ± 0.77^{c}

YC0: plain yogurt, YC1: yogurt with 8% fig powder, YC2: yogurt with 10% fig powder, YC3: yogurt with 12% fig powder. Data were represented as mean ± SEM. Data in the same column with different letters indicated significant differences at $p < 0.05$ by mean of the Tukey's test.

texture, and overall acceptability). All the scores of goat's milk yogurts with fig powder were higher compared to those of plain yogurt. Adding fig powder improved yogurt aroma and covered the unpleasant flavor of goat's milk, which may be explained by the contribution of fig powder volatile compounds previously identified in this study. Several researchers observed that adding fruit preparations could improve the flavor and the acceptability of goat's milk yogurt and contribute to the development of goat dairy products (Feng et al., 2018; Ranadheera et al., 2012; Silva et al., 2017).

The use of fig powder as a natural sweetener and as substituent of sucrose gave a balanced equilibrium between acid and sweet tastes, which constitute a crucial factor in the higher acceptability of goat's milk yogurt with fig powder by consumers.

Goat's milk yogurt supplemented with 12% of fig powder recorded the highest scores for all the sensory attributes. The panelists reported that this preparation had an attractive brown-light color, a consistent texture and a pleasant aroma and taste of caramelized figs.

CONCLUSION

Fig powder of Bakkor Khal variety is a good source of carbohydrates, minerals and proteins. The aromatic profile of fig powder showed different groups of volatiles where, fatty acids, esters and ethers, aldehydes, alcohols, terpenoids, and sterols were prominent. The acidity and the lactic acid bacterial counts increased in the goat's milk yogurt supplemented with fig powder compared to the plain yogurt. The addition of fig powder to goat's yogurt improved its organoleptic quality and acceptability by consumers and might enhance its healthy characteristics.

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