ACTA SCIENTIARUM POLONORUM
Acta Sci. Pol. Technol. Aliment. 24(2) 2025, 271–282
www.food.actapol.net pISSN 1644-0730 eISSN 1898-9594 http://doi.org/10.17306/J.AFS.001203

ORIGINAL PAPER

Received: 24.01.2024
Accepted: 09.04.2024

MANUFACTURING OF FUNCTIONAL KARISH CHEESE FORTIFIED WITH VITAMIN C AND CALCIUM FROM NATURAL SOURCES

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ABSTRACT

Background. Plant-based additives are increasingly used in the dairy industry for their functional and nutritional benefits. Incorporating plant residues or by-products into dairy products such as cheese, yoghurt and Labneh can enhance their nutritional value. This study aimed to improve the nutritional properties of Karish cheese by fortifying it with plant sources such as guava and lemon leaves, which are rich in vitamins, and essential minerals.

Materials and methods. Fresh guava and lemon leaves were added to Karish cheese at concentrations of 0.25%, 0.50% and 0.75%. The physicochemical, microbiological, rheological, antioxidant, and organoleptic properties, as well as bioactive compounds (total phenolic and total flavonoid content), were assessed during storage at 5 ±1°C for 21 days. Nutritional content, including selected minerals and vitamins, was evaluated in fresh samples.

Results. The addition of guava and lemon leaves significantly affected the moisture, protein, SN, ash, acidity and pH of Karish cheese. Fortified samples exhibited elevated levels of essential minerals (Ca, Fe, Mg, P, K and Zn) and vitamins (B_1, B_2, B_3, B_6, A, C and E). Cheeses enriched with guava leaves showed significantly higher ($p \leq 0.05$) antioxidant activity, total phenols, and flavonoid contents than those with lemon leaves. Total bacterial counts were higher in the fortified treatments compared to the control, but coliforms were undetectable across all treatments throughout storage. Texture profile analysis revealed significant increases ($p \leq 0.05$) in hardness, cohesiveness, gumminess, and chewiness and decreases in adhesiveness and springiness. All cheese treatments were found to be organoleptically acceptable, with the highest overall acceptability recorded for cheese fortified with 0.25% guava and lemon leaves.

Conclusion. Fresh guava and lemon leaves can be effectively used to fortify Karish cheese at levels up to 0.75%, enhancing its nutritional, functional and sensory qualities without compromising overall acceptability.

Keywords: guava leaves, lemon leaves, Karish cheese, functional properties, nutritional properties, acceptable organoleptically

INTRODUCTION

Cheese is a staple component of the Egyptian diet, with Karish cheese being one of the most popular traditional soft fresh cheeses (Abou-Donia, 2008). Its widespread consumption is largely attributed to its high protein and low-fat content, good nutritional value, ease of digestibility, and affordability. Additionally, Karish cheese is considered beneficial for individuals with specific health conditions such as hypertension and cardiovascular diseases (Abd-El-Salam et al., 1984; Sagdic et al., 2010). However, due to the acid coagulation

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method used in its production, Karish cheese has relatively low calcium levels. This process alters the balance between colloidal and ionic calcium in the milk, resulting in the conversion of colloidal calcium to its ionic form, which is subsequently lost in the whey – leading to the loss of approximately two-thirds of the total calcium content.

In recent years, consumer food choices have become increasingly influenced by convenience, taste, and health and nutritional value. As a result, the demand for functional foods has grown significantly. Since 1994, considerable attention has been directed toward the antioxidant properties of natural compounds found in fruits and vegetables, which are known to help reduce oxidative stress (Thomas, 1994). More recently, there has been growing interest in using plant-by products as natural sources of antioxidants and antimicrobial agents. Epidemiological studies have shown that diets rich in natural antioxidants can enhance plasma antioxidant capacity and reduce the risk of chronic such as cancer and cardiovascular conditions. These beneficial effects are often attributed to a wide range of phytochemicals, including vitamins, minerals, and dietary fiber, particularly in citrus fruits (Benavente-Garcia and Castillo, 2008; Su et al., 2008; Rohman et al., 2010).

Guava (*Psidium guajava* L.), a tropical a fruit common in regions of America, Asia, and Africa, is known for its rich nutritional and phytochemical profile. Guava leaves are particularly abundant in antioxidants, vitamin C, potassium, calcium, iron and dietary fiber. They contain a diverse array of bioactive compounds such as flavonoids (especially quercetin), saponins, tannins, ascorbic acid, citric acid, alkaloids anthraquinones, phlobatannins and cardiac glycosides. Despite their moderate protein content (10–14% DM), guava leaves are notable for their high fiber content (ADF 27–39% DM) and elevated levels of tannins (10–15% DM). Volatile compounds such as limonene (42.1%) and caryophyllene (21.3%) are also present. According to Sanchez et al. (2000), the primary volatile compounds in guava leaves include αpinene (11.77%), epi-α- bisabolol (10.85%), 1.8- cineol (9.22%), 1-epicubenol (8.56%), globulol (5.88%), thujone (5.35%), hexenal (5.03%), and terpineol (4.35%). Guava leaves also contain calcium oxalate crystals and are traditionally used to treat gastrointestinal disorders such as diarrhea and gastroenteritis. Their flavonoid content contributes to their antibacterial and medicinal properties (Pino et al., 2001; Ogunwande et al., 2003; Suchitra and Wanapat, 2008; Fu et al., 2010).

Lemon leaves are another valuable plant source, particularly rich in vitamin C, with 100 g providing approximately 64% of the daily value. They also contain substantial amounts of vitamins B_2, B_3, calcium, phosphorus, iron and dietary fibers. In addition, lemon leaves are rich in phytochemicals, including polyphenols, terpenes and tannins, and they possess a complex blend of essential oils. These include limonene, betapinene, myrcene, neral, geranial, and beta-caryophyllene. The volatile oil fraction comprises 85–99% of the total oil content and contains a variety of monoterpenes, sesquiterpenes, and their oxygenated derivatives. Non-volatile constituents include hydrocarbons, flavonoids, sterols, fatty acids, coumarins, waxes, carotenoids and psoralens (Penniston et al., 2008; Rauf et al., 2014; Hojjati and Barzegar, 2017).

MATERIALS AND METHODS

Materials

Fresh skimmed buffalo's milk was obtained from the herd of the Faculty of Agriculture, Cairo University. The Yoghurt starter culture, consisting of *Streptococcus salivarius* subsp. *thermophillus* and *Lactobacillus delbruckii* subsp. *bulgaricus* (1:1) was sourced from Chr. Hansen's Laboratory (Copenhagen, Denmark). Sodium chloride was purchased from the local market. Fresh guava (*Psidium guajava* L.) and lemon leaves (*Citrus limon* L.) were collected from trees grown at the farm of Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. All fresh leaves were cleaned, thoroughly washed with tap water, milled into fine pieces and used immediately.

Methods

Cheese manufacture

Karish cheese was prepared following the method described by Fahmi (1960). Skimmed buffalo's milk (0.4% fat, 10.52% SNF) was heated to 85ºC for 15 seconds, then cooled to 38–40ºC. The starter culture of *Str. thermophilus* and *Lb. bulgaricus* was added (3% w/w) and incubated at 42ºC until curd formulation. The curd was then transferred into plastic frames lined with muslin cloth.

Salt (sodium chloride) 1% was sprinkled over the surface of the curd. The curd was then divided into seven equal portions as follows:

- **control (C):** no plant additives
- **guava leaf treatments:** TG_1 (0.25%), TG_2 (0.50%), and TG_3 (0.75%)
- **lemon leaf treatments:** TL_4 (0.25%), TL_5 (0.50%), and TL_6 (0.75%).

Each treatment was mixed with the designated amount of fresh leaf material, pressed under appropriate weight, and stored at 5ºC ±2 for 21 days.

Analytical methods

Chemical analysis

Moisture, protein, soluble nitrogen and ash contents were determined according to (AOAC, 2007). Titratable acidity and pH values were measured as per BSI (2010). Minerals content was analyzed using absorption spectrophotometry (Varian Model Spectra AA 100 & 200) following AOAC (2000) guidelines.

Vitamins B and C were quantified by high-performance liquid chromatography (HPLC) following the method of Ciulu et al. (2011), while vitamins A and E were determined using the method of Leth and Sonderyaro (1993).

Antioxidant activity

The antioxidant activity was assessed using the 2,2-Diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging method described by Olivera et al. (2006). Briefly, 3.9 mL of 0.15 mM DPPH solution was mixed with 0.1 mL of the sample. The mixture was incubated in the dark place at room temperature for 30 minutes. Absorbance was measured at 515 nm using a UV-visible spectrophotometer (Shimadzu 1201). Antioxidant activity was calculated using the formula:

$$\text{Antioxidant activity (\%)} = \frac{A - B}{A} \times 100$$

where:

A – absorbance of pure DPPH in oxidized form

B – absorbance of the sample after 30 minutes.

Total phenolic content was determined according to Zheng and Wang (2001), and total flavonoid content was measured following the method of Olajire and Azeez (2011).

Texture profile analysis

Texture profile analysis was conducted at 23ºC using a Universal Testing Machine (TMS-Pro, Food Technology Corporation, Sterling, VA, USA) fitted with a 250 lbf load cell and connected to a computer equipped with Texture Pro™ software (program: DEV TPA with hold). The parameters measured included hardness, cohesiveness, gumminess, chewiness, adhesiveness, and springiness, as described by Bourne (1982).

Microbiological analysis

Microbiological evaluation included the determination of total bacterial count, yeast and mold count, and coliforms. Analyses were carried out according to Vadderzant and Splittsolesser (2005) using appropriate selective media for each microorganism group.

Organoleptic evaluation

Sensory evaluation was performed by a panel of ten trained staff members from the Dairy Research Department, Food Technology Research Institute. Samples were scored for flavor (30 points), body & texture (60 points) and appearance (10 points) (Bodyfelt et al., 1988).

Statistical analysis

Data were analyzed using the Statistical Analysis System Software package (SAS, 2013). Means were compared using Duncan's multiple range test, and statistical significance was considered at ($p \leq 0.05$).

RESULTS AND DISCUSION

The gross chemical composition and antioxidant activity of guava and lemon leaves are presented in Table 1. Fresh guava leaves exhibited higher moisture, ash content, antioxidant activity, total phenolic content, and total flavonoid content compared to fresh lemon leaves. These findings suggest that both guava and lemon leaves are rich sources of essential minerals such as Ca, Mg, P, K, Fe and Mn, with guava leaves generally containing higher levels of these minerals than lemon leaves.

The chemical composition of fresh and stored Karish cheese samples (stored at 5ºC for 21 days) fortified with guava and lemon leaves is summarized in Table 2. The data indicate that the addition of guava

Table 1. Chemical composition of guava and lemon leaves powder

Components	Guava leaves	Lemon leaves
Moisture, %	82.47	80.52
Ash, %	3.64	2.57
Antioxidant activity, %	80.50	80.31
Total phenolic content mg GAE/100 g	474.29	472.21
Total flavonoid contents mg QE/100 g	80.43	79.11
Minerals, mg/100 g DW		
Ca	1 685	1 460
Mg	438	301
P	366	322
K	1 590	1 010
Fe	13.50	6.23
Mn	103.12	94.65

GAE – gallic acid equivalents, QE – auercetin equivalents, DW – dry weight.

and lemon leaves significantly affected the moisture content of Karish cheese. The control sample (without leaves) had the highest moisture content, while the fortified samples showed progressively lower moisture levels. This reduction could be due to the higher TS present in guava and lemon leaves compared to milk. Moisture content declined gradually throughout the storage period, although the differences among treatments were not statistically significant ($p \leq 0.05$).

Protein content in the fortified cheeses was slightly lower than in the control, while ash content was higher in all treatments containing guava or lemon leaves. Soluble nitrogen (SN) content was highest in the control sample (0.40 ±0.01%), followed by the cheese samples treated with increasing levels of guava and lemon leaves, as follows:

- guava leaf-treated cheeses: 0.39 ±0.01% (0.25%), 0.38 ±0.01% (0.50%), 0.32 ±0.01% (0.75%)
- lemon leaf-treated cheeses: 0.38 ±0.01% (0.25%), 0.35 ±0.01% (0.50%), 0.31 ±0.01% (0.75%).

Soluble nitrogen content increased over the storage periods in all treatments, which might be due to protein hydrolysis. These findings are consistent with those reported by Salem et al. (2013), Ismail et al. (2016), El-Taweel et al. (2017), and Abd-El Rahim et al. (2020).

Changes in titratable acidity and pH are critical, as they influence both the shelf-life organoleptic properties of cheese. Acidity and pH values were measured in all fresh and stored cheese samples. As shown in Figures 3 and 4, titratable acidity increased with higher concentrations of guava and lemon leaves and continued to rise during the 21-day storage period. This increase may be attributed to the production of lactic acid resulting from microbial metabolism (Abd-Allah et al., 1993).

From the data in Table 3, it is evident that the addition of guava and/or lemon leaves to Karish cheese resulted in higher levels of Ca, Fe, Mg, P, K and Zn, attributed to the naturally high concentrations of these

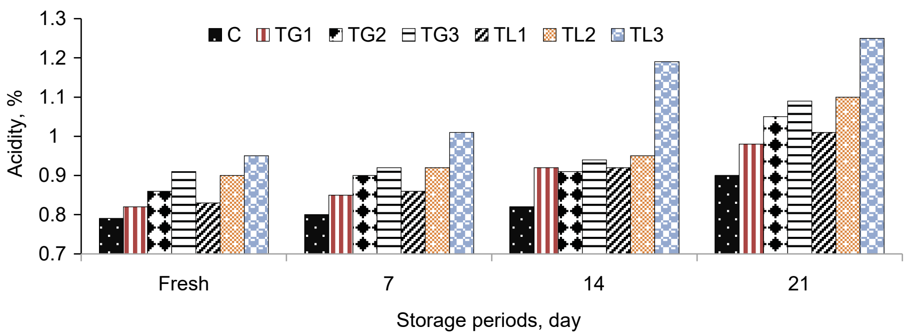

Fig. 1. Acidity (%) of Karish cheese fortified with guava and lemon leaves

Table 2. Chemical composition of fresh and stored Karish cheese fortified with guava and lemon leaves

Constituent %	Storage period day	Treatments						
		C	guava leaves			lemon leaves		
			TG_1	TG_2	TG_3	TL_1	TL_2	TL_3
Moisture	fresh	$75.70^{Aa} \pm 0.19$	$75.66^{Aa} \pm 0.16$	$75.65^{Aa} \pm 0.21$	$75.61^{Aa} \pm 0.30$	$75.69^{Aa} \pm 0.15$	$75.65^{Aa} \pm 0.15$	$75.64^{Aa} \pm 0.20$
	7	$74.47^{Ab} \pm 0.21$	$74.45^{Ab} \pm 0.15$	$74.44^{Ab} \pm 0.21$	$74.43^{Ab} \pm 0.45$	$74.45^{Ab} \pm 0.19$	$74.51^{Ab} \pm 0.15$	$74.40^{Ab} \pm 0.20$
	14	$73.42^{Ac} \pm 0.30$	$73.38^{Ac} \pm 0.13$	$73.36^{Ac} \pm 0.21$	$73.37^{Ac} \pm 0.37$	$73.40^{Ac} \pm 0.21$	$73.38^{Ac} \pm 0.14$	$73.43^{Ac} \pm 0.20$
	21	$71.37^{Ad} \pm 0.26$	$71.33^{Ad} \pm 0.29$	$71.31^{Ad} \pm 0.21$	$71.29^{Ad} \pm 0.28$	$71.35^{Ad} \pm 0.25$	$71.30^{Ad} \pm 0.19$	$71.28^{Ad} \pm 0.25$
Protein	fresh	$15.72^{Ac} \pm 0.13$	$15.67^{Ab} \pm 0.11$	$15.41^{Bc} \pm 0.12$	$15.32^{Bb} \pm 0.13$	$15.65^{Ab} \pm 0.12$	$15.40^{Bc} \pm 0.10$	$15.30^{Bb} \pm 0.10$
	7	$15.87^{Abc} \pm 0.18$	$15.77^{ABb} \pm 0.21$	$15.69^{ABbc} \pm 0.11$	$15.52^{Bb} \pm 0.20$	$15.75^{ABb} \pm 0.18$	$15.66^{ABbc} \pm 0.10$	$15.50^{Bb} \pm 0.10$
	14	$16.13^{Aab} \pm 0.11$	$15.97^{Aab} \pm 0.13$	$15.89^{Aab} \pm 0.14$	$15.89^{Aa} \pm 0.17$	$15.95^{Aab} \pm 0.10$	$15.85^{Aab} \pm 0.14$	$15.87^{Aa} \pm 0.15$
	21	$16.35^{Aa} \pm 0.15$	$16.15^{Aa} \pm 0.19$	$16.08^{Aa} \pm 0.32$	$16.12^{Aa} \pm 0.14$	$16.16^{Aa} \pm 0.15$	$16.05^{Aa} \pm 0.22$	$16.10^{Aa} \pm 0.15$
SN	fresh	$0.40^{Ac} \pm 0.01$	$0.39^{Aa} \pm 0.01$	$0.38^{Aa} \pm 0.01$	$0.32^{Ba} \pm 0.01$	$0.38^{Aa} \pm 0.01$	$0.35^{Aa} \pm 0.01$	$0.31^{Ba} \pm 0.01$
	7	$0.42^{Ab} \pm 0.01$	$0.41^{Aa} \pm 0.01$	$0.41^{Aa} \pm 0.01$	$0.35^{Ba} \pm 0.01$	$0.40^{Aa} \pm 0.01$	$0.39^{Aa} \pm 0.01$	$0.33^{Ba} \pm 0.01$
	14	$0.43^{Ab} \pm 0.01$	$0.42^{Ba} \pm 0.01$	$0.42^{Cb} \pm 0.01$	$0.36^{Db} \pm 0.01$	$0.41^{Aa} \pm 0.01$	$0.40^{Cb} \pm 0.01$	$0.35^{Db} \pm 0.01$
	21	$0.45^{Aa} \pm 0.01$	$0.44^{Ba} \pm 0.01$	$0.43^{Cc} \pm 0.01$	$0.38^{Dc} \pm 0.01$	$0.42^{Ba} \pm 0.01$	$0.43^{Cc} \pm 0.01$	$0.37^{Dc} \pm 0.01$
Ash	fresh	$1.43^{Ca} \pm 0.12$	$1.64^{Ba} \pm 0.11$	$1.81^{Ba} \pm 0.12$	$2.11^{Aa} \pm 0.12$	$1.65^{Ba} \pm 0.12$	$1.89^{Ba} \pm 0.11$	$2.20^{Aa} \pm 0.10$
	7	$1.45^{Ca} \pm 0.11$	$1.68^{Ba} \pm 0.18$	$1.85^{Ba} \pm 0.14$	$2.21^{Aa} \pm 0.10$	$1.66^{Ba} \pm 0.15$	$1.92^{Ba} \pm 0.12$	$2.28^{Aa} \pm 0.10$
	14	$1.46^{Ca} \pm 0.16$	$1.69^{BCa} \pm 0.14$	$1.88^{Ba} \pm 0.09$	$2.34^{Aa} \pm 0.13$	$1.67^{BCa} \pm 0.14$	$1.95^{Ba} \pm 0.10$	$2.32^{Aa} \pm 0.12$
	21	$1.49^{Ca} \pm 0.21$	$1.76^{BCa} \pm 0.12$	$1.92^{Ba} \pm 0.12$	$2.38^{Aa} \pm 0.13$	$1.72^{BCa} \pm 0.14$	$1.98^{Ba} \pm 0.12$	$2.35^{Aa} \pm 0.13$

A, B, C & D and a, b, c & d: means with the same letter among treatments and the storage periods respectively are not significantly different ($p \leq 0.05$).

C – control TG_1, TL_1:0.25% guava leaves, lemon leaves; TG_2, TL_2: 0.50% guava leaves, lemon leaves; TG_3, TL_3: 0.75% guava leaves, lemon leaves.

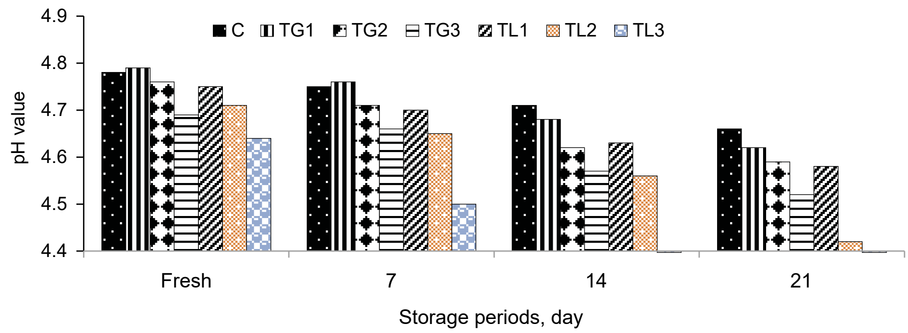

Fig. 2. pH values of Karish cheese fortified with guava and lemon leaves

Table 3. Mineral and vitamin content of Karish cheese fortified with guava and lemon leaves

Component	Treatments*						
	C	guava leaves			lemon leaves		
		TG_1	TG_2	TG_3	TL_1	TL_2	TL_3
Minerals, mg/100 g							
Ca	567	590	605	620	584	602	618
Fe	0.7	1.05	1.52	1.98	1.22	1.67	2.05
Mg	33	45	57	68	38	50	59
P	514	595	645	735	581	632	711
K	2.05	4.11	7.95	10.13	3.95	551	6.88
Zn	1.95	3.55	5.11	6.78	3.15	4.45	6.45
Vitamins, 100 g							
B_1, µg	110	124	145	165	125	141	158
B_2, µg	380	422	455	510	395	440	489
B_3, µg	9	31	55	85	26	33	66
B_6, µg	81	110	145	156	105	122	145
A, µg	77	86	95	112	81	86	92
C, mg	0.6	10.61	11.33	12.06	6.56	7.11	7.42
E, µg	45	66	84	105	54	64	78

*See footnote of Table 2 for details.

minerals in the leaves. Cheese fortified with lemon leaves showed higher iron content, whereas samples fortified with guava leaves exhibited greater concentrations of Ca, Mg, P, K, and Zn compared to those treated with lemon leaves alone. These findings suggest that the fortified cheese could serve as a valuable dietary source of several essential minerals, especially calcium and phosphorus (Ismail et al., 2016).

In terms of vitamin content, the incorporation of guava and lemon leaves led to increased levels of vitamins vitamin B_1 (thiamine), B_2 (riboflavin), B_3 (niacin), B_6 (pyridoxine), A (ß-carotene), C (ascorbic acid) and vitamin E (α- tocopherol), as shown in Table 3. For example, vitamin A increased from 77 µg in the control to 112 µg and 92 µg, while vitamin C increased from 0.6 mg to be 12.06 mg and 7.42 mg in Karish cheese treated with 0.75% of guava and lemon leaves, respectively. These increases are due to the high vitamin content naturally present in the leaves. Similar results were reported by Salem et al. (2013) and El-Nawasany et al. (2015).

According to Table 4, Karish cheese fortified with guava leaves had significantly higher ($p \leq 0.05$) higher antioxidant activity, total phenols, and total flavonoid content compared to cheese fortified with lemon leaves. However, these bioactive active compounds and antioxidant activities significantly decreased ($p \leq 0.05$) during cold storage due to their low stability. These results align with findings by Salem et al. (2013) and El-Gazzar et al. (2018).

The incorporation of guava and lemon leaves also influenced the cheese's textural properties (Table 5). Specifically, hardness, cohesiveness, gumminess and chewiness increased significantly ($p \leq 0.05$), while adhesiveness and springiness decreased. This may be due to reduced moisture content caused by the

Table 4. Total phenolic content, total flavonoid content, and antioxidant activity (%) of fresh and stored Karish cheese fortified with guava and lemon leaves

Property	Storage period day	Treatments*						
		C	guava leaves			lemon leaves		
			TG_1	TG_2	TG_3	TL_1	TL_2	TL_3
Total phenols mg GAE/100 g	fresh	4.86^{Da} ±0.01	51.23^{Ca} ±0.11	74.25^{Ba} ±0.07	97.54^{Aa} ±0.01	50.45^{Ca} ±0.07	71.78^{Ba} ±0.02	94.34^{Aa} ±0.01
	7	4.15^{Da} ±0.15	48.21^{Ca} ±0.04	70.28^{Ba} ±0.25	92.15^{Aa} ±0.13	45.31^{Ca} ±0.01	66.22^{Ba} ±0.05	89.35^{Aa} ±0.08
	14	3.95^{Da} ±0.05	44.44^{Ca} ±0.09	65.98^{Bb} ±0.35	90.78^{Aa} ±0.04	40.17^{Ca} ±0.01	62.81^{Bab} ±0.16	85.86^{Aa} ±0.05
	21	3.15^{Db} ±0.05	39.45^{Cb} ±0.07	63.12^{Bb} ±0.14	85.47^{Ab} ±0.09	38.23^{Ca} ±0.02	59.58^{Bb} ±0.08	82.38^{Aa} ±0.05
Total flavonoid mg QE/100 g	fresh	2.85^{Ba} ±0.03	8.78^{Aa} ±0.05	9.14^{Aa} ±0.03	9.76^{Aa} ±0.05	8.45^{Aa} ±0.02	8.88^{Aa} ±0.00	9.57^{Aa} ±0.09
	7	2.45^{Ba} ±0.26	8.41^{Aa} ±0.05	9.07^{Aa} ±0.09	9.56^{Aa} ±0.07	8.15^{Aa} ±0.06	8.54^{Aa} ±0.05	9.34^{Aa} ±0.04
	14	2.31^{Ba} ±0.05	8.32^{Aa} ±0.08	9.02^{Aa} ±0.11	9.25^{Aa} ±0.07	7.99^{Aa} ±0.15	8.21^{Aa} ±0.12	9.01^{Aa} ±0.07
	21	2.18^{Ba} ±0.14	8.15^{Aa} ±0.01	8.77^{Aa} ±0.07	8.94^{Aa} ±0.07	7.84^{Aa} ±0.09	8.12^{Aa} ±0.07	8.44^{Ab} ±0.06
Antioxidant activity, %	fresh	20.15^{Ca} ±0.12	39.78^{Ba} ±0.02	47.44^{ABa} ±0.08	55.21^{Aa} ±0.12	38.25^{Ba} ±0.33	44.24^{Ba} ±0.09	52.23^{Aa} ±0.05
	7	16.26^{Ca} ±0.21	35.31^{Ba} ±0.02	42.19^{Ba} ±0.05	50.06^{Aa} ±0.07	35.08^{Ba} ±0.06	40.46^{Ba} ±0.09	48.34^{Aa} ±0.03
	14	14.53^{Ca} ±0.33	30.22^{Bb} ±0.03	40.71^{Aab} ±0.03	48.42^{Aa} ±0.08	30.34^{Bb} ±0.21	38.71^{Ab} ±0.07	45.54^{Aa} ±0.14
	21	12.45^{Ca} ±0.09	28.45^{Bb} ±0.03	38.48^{Ab} ±0.05	45.89^{Ab} ±0.15	27.27^{Bb} ±0.09	36.80^{Ab} ±0.02	42.77^{Ab} ±0.10

*See footnote of Table 2 for details.

Table 5. Textural properties of fresh and stored Karish cheese fortified with guava and lemon leaves

Property	Storage period (day)	Treatments*						
		C	guava leaves			lemon leaves		
			TG_1	TG_2	TG_3	TL_1	TL_2	TL_3
1	2	3	4	5	6	7	8	9
Hardness, N	fresh	2.05^{Bb} ±0.15	2.27^{Ac} ±0.10	2.32^{Ac} ±0.12	2.36^{Ac} ±0.06	2.31^{Ac} ±0.17	2.35^{Ac} ±0.12	2.40^{Ac} ±0.06
	7	2.30^{Ba} ±0.06	2.41^{Bb} ±0.26	2.55^{Bb} ±0.27	2.69^{Ab} ±0.25	2.62^{Ab} ±0.50	2.84^{Ab} ±0.15	2.74^{Ab} ±0.22
	14	2.32^{Ba} ±0.03	2.68^{ABb} ±0.29	2.81^{Aa} ±0.05	2.94^{Aa} ±0.01	2.75^{Ab} ±0.06	2.99^{Aa} ±0.27	3.05^{Aa} ±0.01
	21	2.44^{Ba} ±0.10	3.05^{Aa} ±0.42	3.11^{Aa} ±0.40	3.16^{Aa} ±0.46	3.12^{Aa} ±0.12	3.28^{Aa} ±0.06	3.29^{Aa} ±0.45
Cohesiveness ratio	fresh	0.53^{Ac} ±0.02	0.55^{Ab} ±0.02	0.57^{Ac} ±0.02	0.58^{Ab} ±0.02	0.56^{Ac} ±0.02	0.57^{Ab} ±0.02	0.59^{Ab} ±0.02
	7	0.56^{Ab} ±0.05	0.58^{Ab} ±0.04	0.59^{Ac} ±0.01	0.64^{Aa} ±0.03	0.58^{Ac} ±0.00	0.60^{Ab} ±0.03	0.61^{Ab} ±0.04
	14	0.61^{Aab} ±0.03	0.63^{Aa} ±0.01	0.65^{Ab} ±0.03	0.64^{Aa} ±0.04	0.63^{Ab} ±0.03	0.67^{Aa} ±0.04	0.68^{Aa} ±0.01
	21	0.66^{Aa} ±0.05	0.67^{Aa} ±0.05	0.69^{Aa} ±0.03	0.70^{Aa} ±0.01	0.68^{Aa} ±0.03	0.70^{Aa} ±0.01	0.71^{Aa} ±0.05
Gumminess N	fresh	1.09^{Cc} ±0.15	1.25^{Bc} ±0.15	1.32^{Ac} ±0.05	1.37^{Ac} ±0.15	1.29^{Bc} ±0.06	1.34^{Ac} ±0.05	1.42^{Ac} ±0.06
	7	1.29^{Cbc} ±0.35	1.40^{Bbc} ±0.06	1.50^{Bc} ±0.08	1.72^{Ab} ±0.35	1.52^{Bb} ±0.08	1.70^{Abc} ±0.08	1.67^{Ab} ±0.08
	14	1.42^{Cb} ±0.01	1.69^{BCb} ±0.03	1.83^{Bb} ±0.08	1.88^{Ab} ±0.01	1.73^{Bb} ±0.04	2.00^{Ab} ±0.08	2.07^{Aa} ±0.04
	21	1.61^{Ca} ±0.10	2.04^{Ba} ±0.10	2.15^{Ba} ±0.00	2.21^{Aa} ±0.10	2.12^{Ba} ±0.03	2.30^{Aa} ±0.01	2.34^{Aa} ±0.03

Table 5 – cont.

1	2	3	4	5	6	7	8	9
Chewiness, mj	fresh	$2.60^{Cb} \pm 0.39$	$2.97^{Aa} \pm 0.18$	$3.05^{Ab} \pm 0.10$	$2.79^{Bb} \pm 0.26$	$3.04^{Ac} \pm 0.39$	$3.07^{Ab} \pm 0.18$	$2.83^{Bb} \pm 0.30$
	7	$2.90^{Ba} \pm 0.26$	$2.71^{Cb} \pm 0.10$	$3.34^{Aa} \pm 0.02$	$3.18^{Aa} \pm 0.75$	$3.34^{Ab} \pm 0.26$	$3.36^{Aa} \pm 0.10$	$2.99^{Bb} \pm 0.07$
	14	$2.89^{Ba} \pm 0.20$	$2.75^{Bb} \pm 0.15$	$3.11^{ABb} \pm 0.07$	$3.16^{Aa} \pm 0.49$	$3.40^{Ab} \pm 0.20$	$3.31^{Aa} \pm 0.15$	$3.32^{Aa} \pm 0.02$
	21	$3.00^{Ca} \pm 0.28$	$3.31^{Ba} \pm 0.17$	$3.35^{Ba} \pm 0.30$	$3.23^{Ba} \pm 0.46$	$3.71^{Aa} \pm 0.28$	$3.44^{Aa} \pm 0.17$	$3.25^{Ba} \pm 0.10$
Adhesiveness mJ	fresh	$0.57^{Aa} \pm 0.02$	$0.55^{Aa} \pm 0.14$	$0.51^{Aa} \pm 0.08$	$0.48^{Aa} \pm 0.04$	$0.48^{Aa} \pm 0.14$	$0.45^{Aa} \pm 0.08$	$0.42^{Aa} \pm 0.01$
	7	$0.50^{Aa} \pm 0.01$	$0.51^{Aa} \pm 0.02$	$0.41^{Aab} \pm 0.06$	$0.41^{Aa} \pm 0.02$	$0.42^{Aa} \pm 0.10$	$0.39^{Aab} \pm 0.06$	$0.39^{Aa} \pm 0.02$
	14	$0.41^{Aa} \pm 0.01$	$0.45^{Aa} \pm 0.03$	$0.38^{Ab} \pm 0.01$	$0.38^{Aa} \pm 0.02$	$0.35^{Aa} \pm 0.03$	$0.32^{Ab} \pm 0.01$	$0.34^{Aa} \pm 0.02$
	21	$0.39^{Aa} \pm 0.06$	$0.40^{Aa} \pm 0.03$	$0.35^{Ab} \pm 0.02$	$0.32^{Aa} \pm 0.01$	$0.31^{Aa} \pm 0.03$	$0.30^{Ab} \pm 0.02$	$0.29^{Aa} \pm 0.04$
Springiness mm	fresh	$2.39^{Aa} \pm 0.25$	$2.38^{Aa} \pm 0.12$	$2.31^{Aa} \pm 0.05$	$2.04^{Ba} \pm 0.51$	$2.35^{Aa} \pm 0.25$	$2.29^{Aa} \pm 0.05$	$2.00^{Ba} \pm 0.51$
	7	$2.25^{Aa} \pm 0.31$	$1.94^{Bb} \pm 0.08$	$2.22^{Ab} \pm 0.07$	$1.85^{Bab} \pm 0.19$	$2.20^{Aa} \pm 0.31$	$1.97^{Bb} \pm 0.07$	$1.79^{Bab} \pm 0.19$
	14	$2.04^{Ab} \pm 0.20$	$1.63^{Bc} \pm 0.20$	$1.70^{Bb} \pm 0.08$	$1.68^{Bb} \pm 0.11$	$1.96^{Ab} \pm 0.20$	$1.65^{Bb} \pm 0.08$	$1.60^{Bb} \pm 0.11$
	21	$1.86^{Ab} \pm 0.04$	$1.62^{Ac} \pm 0.03$	$1.56^{Ac} \pm 0.11$	$1.46^{ABb} \pm 0.09$	$1.75^{Ab} \pm 0.01$	$1.50^{Ac} \pm 0.11$	$1.39^{Bb} \pm 0.09$

A, B, C & D and a, b, c & d: means with the same letter among treatments and the storage periods respectively are not significantly different ($p \leq 0.05$).
*See footnote of Table 2 for details.

water-binding capacity of the added leaves, as moisture reduction weakness the casein curd (El-Taweel et al., 2017). These textural changes continued during storage, possibly due to the proteolysis, which contributes to a smoother, more refined cheese texture (Molander et al., 1990).

Table 6 presents changes in the total bacterial count during refrigerated storage (5 ±ºC). Treatments

Table 6. Microbiological analysis (log cfu/g) of fresh and stored Karish cheese fortified with guava and lemon leaves

Property	Storage period day	Treatments*						
		C	guava leaves			lemon leaves		
			TG_1	TG_2	TG_3	TL_1	TL_2	TL_3
Total bacterial count	fresh	$7.20^{Cc} \pm 0.03$	$7.32^{BCc} \pm 0.02$	$7.52^{ABc} \pm 0.05$	$7.77^{Ab} \pm 0.08$	$7.28^{Cc} \pm 0.62$	$7.44^{Bc} \pm 0.01$	$7.59^{Ab} \pm 0.33$
	7	$7.62^{Cb} \pm 0.02$	$7.80^{Bb} \pm 0.29$	$7.99^{Ab} \pm 0.04$	$8.12^{Aab} \pm 0.20$	$7.78^{Bb} \pm 0.14$	$7.82^{Bb} \pm 0.02$	$8.05^{Aa} \pm 0.12$
	14	$8.21^{Aa} \pm 0.01$	$8.42^{Aa} \pm 0.03$	$8.55^{Aa} \pm 0.18$	$8.61^{Aa} \pm 0.25$	$8.33^{Ba} \pm 0.00$	$8.44^{Ba} \pm 0.13$	$8.50^{Aa} \pm 0.20$
	21	$8.05^{Aa} \pm 0.22$	$8.23^{Aa} \pm 0.05$	$8.31^{Aa} \pm 0.21$	$8.45^{Aa} \pm 0.05$	$8.19^{Aa} \pm 0.27$	$8.24^{Aa} \pm 0.35$	$8.28^{Aa} \pm 0.41$
Yeasts & molds	fresh	$2.83^{Ab} \pm 0.33$	$2.32^{Ac} \pm 0.42$	ND	ND	$2.25^{Ac} \pm 0.63$	$1.94^{Bb} \pm 0.29$	ND
	7	$3.15^{Ab} \pm 0.05$	$3.08^{Ab} \pm 0.23$	$2.96^{Ab} \pm 0.44$	$2.90^{Ab} \pm 0.18$	$3.15^{Abc} \pm 0.19$	$3.11^{Aa} \pm 0.28$	$2.61^{Bb} \pm 0.42$
	14	$3.62^{Aa} \pm 0.31$	$3.54^{Aa} \pm 0.08$	$3.24^{Aa} \pm 0.51$	$3.11^{Aa} \pm 0.09$	$3.44^{Ab} \pm 0.01$	$3.32^{Aa} \pm 0.17$	$3.05^{Aa} \pm 0.30$
	21	$3.91^{Aa} \pm 0.11$	$3.68^{Aa} \pm 0.15$	$3.45^{Aa} \pm 0.06$	$3.22^{Aa} \pm 0.26$	$3.81^{Aa} \pm 0.22$	$3.55^{Aa} \pm 0.03$	$3.38^{Aa} \pm 0.21$

*See footnote of Table 2 for details.
ND – not detected.

containing guava leaves or lemon leaves exhibited higher bacterial counts than the control, likely due to the nutritional richness of the leaves, including carbohydrates, proteins, minerals and vitamins. Increasing leaf concentrations further promoted bacterial growth. Notably, cheese made with guava leaves had higher bacterial counts than those made with lemon leaves. Bacterial visibility remained high for the first 14 days of cold storage, then started to decline. These findings are consistent with Salem et al. (2013). Yeasts and mold counts increased gradually throughout storage period, with guava leaf treatments showing the highest count. Coliform bacteria were not detected in any treatment, either fresh or during storage (Awad, 2016; Abd El-Sattar et al., 2020).

Sensory evaluation results, as shown in Table 7, revealed significant differences ($p \leq 0.05$) between fresh and stored cheese samples. The addition of guava and lemon leaves led to statistically significant improvements in body and texture scores, particularly at 0.25% and 0.5% concentrations. Treatments (TL_1) (lemon leaves, 0.25%) and TG1 (guava leaves, 0.25%) achieved the highest scores of 29.67 and 29.60 points, respectively. Flavor scores also peaked at up to 0.5% leaf addition, with TL_1 and TG_1 being the most preferred. These improvements may be linked be linked to the formation of flavor compounds such as acetaldehyde and short-chain fatty acids due to carbohydrate degradation (Zayan, 2016). No significant differences ($p \leq 0.05$) were found in general appearance across

Table 7. Sensory evaluation of fresh and stored Karish cheese fortified with guava and lemon leaves

Property	Storage period day	Treatments*						
		C	guava leaves			lemon leaves		
			TG_1	TG_2	TG_3	TL_1	TL_2	TL_3
General appearance (10)	fresh	9.67^{Aa} ±0.57	9.54^{Aa} ±1.01	9.33^{Aa} ±0.56	8.95^{Aa} ±1.50	9.55^{Aa} ±1.00	9.42^{Aa} ±0.50	9.11^{Aa} ±1.52
	7	9.72^{Aa} ±0.08	9.65^{Aa} ±0.51	9.35^{Aa} ±0.50	9.10^{Aa} ±0.55	9.70^{Aa} ±0.50	9.62^{Aa} ±0.58	9.15^{Aa} ±0.58
	14	9.14^{Aab} ±0.59	9.12^{Aa} ±0.57	9.05^{Aa} ±0.42	8.89^{Aa} ±0.54	9.17^{Aa} ±0.58	9.05^{Aa} ±0.51	8.75^{Aa} ±0.52
	21	8.76^{Ab} ±0.29	8.74^{Ab} ±0.30	8.65^{Ab} ±0.55	8.44^{Aa} ±0.30	8.81^{Ab} ±0.29	8.67^{Aa} ±0.50	8.52^{Aa} ±0.29
Body & texture (30)	fresh	29.45^{Aa} ±1.00	29.60^{Aa} ±2.66	29.52^{Aa} ±0.58	29.35^{Aa} ±1.00	29.67^{Aa} ±2.65	29.55^{Aa} ±0.58	29.42^{Aa} ±1.07
	7	29.55^{Aa} ±0.58	29.75^{Aa} ±0.75	29.65^{Aa} ±0.51	29.38^{Aa} ±1.00	29.80^{Aa} ±0.74	29.67^{Aa} ±0.50	29.45^{Aa} ±1.09
	14	29.12^{Aa} ±2.08	29.54^{Aa} ±1.55	29.44^{Aa} ±1.00	28.75^{Ab} ±0.51	29.63^{Aa} ±1.53	29.51^{Aa} ±1.00	28.99^{Aab} ±0.50
	21	28.78^{Aa} ±1.89	29.12^{Aa} ±1.00	28.95^{Aa} ±1.00	28.54^{Ab} ±0.59	29.15^{Aa} ±1.24	29.05^{Aa} ±1.05	28.75^{Ab} ±0.58
Flavor (60)	fresh	55.67^{Ba} ±1.16	57.17^{Aa} ±1.00	56.67^{Aa} ±1.62	55.17^{Ba} ±0.51	58.23^{Aa} ±1.08	57.04^{Aa} ±1.61	55.44^{Ba} ±0.50
	7	56.83^{Ba} ±1.00	58.16^{Aa} ±0.58	58.02^{Aa} ±1.01	55.33^{Ba} ±2.07	59.00^{Aa} ±0.58	57.83^{Aa} ±1.00	56.51^{Ba} ±2.08
	14	55.81^{Ba} ±1.54	56.62^{Aa} ±1.16	56.55^{Aa} ±1.01	54.67^{Ba} ±1.25	57.05^{Ab} ±1.16	56.33^{Aa} ±1.00	55.45^{Ba} ±1.26
	21	55.50^{Aa} ±1.53	56.31^{Aa} ±0.58	55.83^{Aa} ±1.03	54.5^{Aa} ±1.30	56.83^{Ab} ±0.58	56.17^{Aa} ±1.04	55.22^{Aa} ±1.32
Total score (100)	fresh	94.79^{ABab} ±1.00	96.31^{Aab} ±4.01	95.52^{Aa} ±1.80	93.47^{Ba} ±0.29	97.45^{Aa} ±4.00	96.01^{Aa} ±1.80	93.97^{Bb} ±0.29
	7	96.10^{Aa} ±1.04	97.56^{Aa} ±0.59	97.02^{Aa} ±1.61	93.81^{Ba} ±2.66	98.50^{Aa} ±0.58	97.12^{Aa} ±1.61	95.11^{ABa} ±2.65
	14	94.09^{Aab} ±3.97	95.28^{Aab} ±0.57	95.04^{Aa} ±2.08	92.31^{Ba} ±1.58	95.85^{Aab} ±0.58	94.89^{Ab} ±2.08	93.19^{Bb} ±1.53
	21	93.04^{Ab} ±3.40	94.17^{Ab} ±0.30	93.43^{Ab} ±0.58	91.48^{Ab} ±2.01	94.79^{Ab} ±0.32	93.89^{Ab} ±0.58	92.49^{Ab} ±2.00

A, B, C & D and a, b, c & d: means with the same letter among treatments and the storage periods respectively are not significantly different ($p \leq 0.05$).
*See footnote of Table 2 for details.

most treatments, though slight increases in overall sensory scores were noted with 0.25% and 0.5% of leaf additions. Overall, all fortified cheese samples remained organoleptically acceptable throughout the storage period, in agreement with previous studies (Ismail et al., 2016; Peker and Arslan, 2016).

CONCLUSION

Fresh guava and lemon leaves can be incorporated at levels up to 0.75%, with guava leaves yielding the most favorable results, for the production of high-quality, functional Karish cheese. These additions enhance mineral and vitamin content, improve antioxidant properties, and maintain sensory acceptability, making the product a promising natural source of antioxidants, vitamin C, and calcium.

DECLARATIONS

Data statement
All data supporting this study has been included in this manuscript.

Ethical Approval
Not applicable.

Competing Interests
The authors declare that they have no conflicts of interest.

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REFERENCES

Abd-Allah, S. A. M., Abbas, H. M., El-Sayed, N. H., Tawfik (1993). Effect of substitution of soymilk on some chemical properties, formation of biogenic amines and pr-toxin of blue veined cheese. J. Agric. Sci. Mansoura Univ., 18(7), 2002–2010.

Abd-El Rahim, A. M., Sadek, S. H., Mohran, M. A. (2020). Effect of *Thymus vulgaris* aqueous extract on chemical, microbiological and organoleptic properties of Karish cheese. J. Food Dairy Sci., Mansoura Univ., 11(1), 33–38. https://doi.org/10.21608/jfds.2020.77974

Abd-El-Salam, M. H., El-Shibiny, S., El-Alamy, H. A. (1984). Production of skim milk (Karish cheese) from ultrafiltered reconstituted milk. Egypt. J. Dairy Sci., 12(1), 111–115.

Abd El-Sattar, E., Mahetab, F., Abd El-Wahed, E. M. (2020). Production of probiotic low-fat yoghurt supplemented with Guava seeds powder. J. Food Dairy Sci., Mansoura Univ., 11(4), 91–96. https://doi.org/10.21608/jfds.2020.95596

Abou-Donia, S. A. (2008). Origin, history and manufacturing process of Egyptian dairy products: An overview. Alex. J. Food Sci. Technol., 5(1), 51–62. https://doi.org/10.21608/ajfs.2008.20141

AOAC (2000). Association of Official Analytical chemists. Official methods of analysis, 17th ed. Washington, DC: AOAC.

AOAC (2007). Ice cream. In: Dairy products. 18th ed (pp. 72–80). Gaithersburg, MD, USA: Official Methods of Analysis.

Awad, S. (2016). Microbial safety criteria and quality of traditional Egyptian Karish cheese. Afric. J. Micro. Res., 10(22), 804–812. https://doi.org/10.5897/AJMR2016.8022

Benavente-Garcia, O., Castillo, J. (2008). Update on uses and properties of citrus flavonoids: new finding in anticancer, cardiovascular and anti-inflammatory activity. J. Agric. Food Chem., 56(15), 6185–6205. https://doi.org/10.1021/jf8006568

Bodyfelt, F. W., Tobias, J., Trout, G. M. (1988). The sensory evaluation of dairy products. New York: Von Nostrand Reinhold.

Bourne, M. C. (1982). Texture profile analysis. Food Technol., 32, 62–66, 72.

BSI (2010). Dried milk: determination of titratable acidity and pH value (Reference method). ISO, 6091.

Ciulu, M., Solineas, S., Floris, I., Panzanelli, A., Pilo, M. I., …, Sanna, G. (2011). RP-HPLC determination of water-soluble vitamins in honey. Talanta, 83(3), 924–929. https://doi.org/10.1016/j.talanta.2010.10.059

El-Gazzar, H., Moussa, M., Abo El-khair, S. A. A. (2018). Fortification of Labneh with the extract of guava leaves powder as functional products. J. Food and Dairy Sci., Mansoura Univ., 9(4), 139–143. https://doi.org/10.21608/JFDS.2018.35511

El-Nawasany, L. F., Sakr, H. S. A., Aboel-Enin, E. A. (2015). The use of citrus fruits in the manufacture of flavoured Karish cheese. Arab Univ. J. Agric. Sci., Ain Shams Univ., 23(2), 563–570.https://doi.org/10.21608/AJS.2015.14597

El-Taweel, H. S., El-Sisi, A. S., Mailam, M. A. (2017). Improving functional properties of Kareish cheese by adding low sodium salt and dried parsley. Egypt. J. Agric. Res., 95(3), 1179–1191. https://doi.org/10.13140/RG.2.2.30342.32324

Fahmi, A. H. (1960). Kariesh cheese. J. Agric. Sci., 13, 1.

Fu, H. Z., Luo, Y. M., Li, C. J., Yang, J. Z., Zhang, D. M. (2010). Psidials A−C, Three unusual meroterpenoids from the leaves of *Psidium guajava* L. Org. Lett., 12(4), 656–659. https://doi.org/10.1021/ol9024869

Hojjati, M., Barzegar, H. (2017).Chemical composition and biological activities of Lemon (*Citrus limon*) leaf essential oil. Nutri. Food Sci. Res., 4(4), 15–24. https://doi.org/10.29252/nfsr.4.4.3

Ismail, A. I., Zaki, N. L., El-Shazly, H. A. (2016). Labneh fortified with olive leaves as innovative dairy products. J. Food Dairy Sci., Mansoura Univ., 7(10), 415–419. https://doi.org/10.21608/JFDS.2016.46045

Leth, T., Sonderyaro, J. J. (1993). Vitamin A in Danish pig, calf and ox liver. J. Food Comp. Anal., 6(1), 3–9. https://doi.org/10.1006/jfca.1993.1002

Molander, E., Kristiansen, K. R., Werner, H. (1990). Instrumental and sensory measurement of Brie texture. Milchwissenschafft, 45, 589–593.

Ogunwande, I. A., Olawore, N. O., Adeleke, K. A., Ekundayo, O., Koenig, W. (2003). Chemical composition of the leaf volatile oil of *Psidium guajava* L. growing in Nigeria. Flav. Frag. J., 18(2), 136–138. https://doi.org/10.1002/ffj.1175

Olajire, A. A., Azeez, L. (2011). Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. Afr. J. Food Sci. Technol., 2(2), 22–29.

Olivera, P., Mila, J., Mladen, M. (2006). Chemical composition and antioxidant activity of essential oils of twelve spice plants. Croat. Chem. Acta, 79(4), 545–552.

Sagdic, O., Ozturk, I., Kesmen, Z., Yilmaz, M. T. (2010). Characterization of cheese spoiling yeasts and their inhibition by some spices. J. Food Sci., 75(9), 597–603. https://doi.org/10.1111/j.1750-3841.2010.01871.x

Peker, H., Arslan, H. (2016). Effect of olive leaf extract on the quality of low fat apricot yogurt. J. Food Process. Preserv., 41(5), 1–10. https://doi.org/10.1111/jfpp.13107

Penniston, K. L., Nakada, S. Y., Holmes, R. P., Assimos, D. G. (2008). Quantitative assessment of citric acid in lemon juice, lime juice, and commercially-available fruit juice products. J. Endourol., 22(3), 567–570. https://doi.org/10.1089/end.2007.0304

Rauf, A., Uddin, G., Ali, J. (2014). Phytochemical analysis and radical scavenging profile of juices of *Citrus sinensis*, *Citrus anrantifolia*, and *Citrus limonum*. Org. Med. Chem. Lett., 4(1), 5. https://doi.org/10.1186/2191-2858-4-5

Rohman, A., Riyanto, S., Yuniarti, N., Saputra, W. R., Utami, R., Mulatsi, W. (2010). Antioxidant activity, total phenolic and total flavonoid of extracts and fractions of red fruits (*Pandamus conoideus* Lam). Int. Food Res. J. 17(1), 97–106.

Salem, A. S., Salama,W. M., Hassanein, A. M., El Ghandour, H. M. A. (2013). Enhancement of nutritional and biological values of Labneh by adding dry leaves of *Moringa oleifera* as innovative dairy products. World Appl. Sci. J., 22(11), 1594–1602.

Sanchez, G. M., Giuliani, L., Re, M. A., Nunez Selles, A. J., Davison, G. P. Lean-Fernandez, O. S. (2000). Protective effects of *Mangifera indica* L. extract, mangiferin and selected antioxidants against TPA – induced biomolecules oxidation and peritoneal macrophage activation in mice. Pharmacol. Res., 42(6), 565–573. https://doi.org/10.1006/phrs.2000.0727

SAS (2013). Statistical Analysis: System User Guide. Version 9.3. Cary, NC, US: SAS Institute Inc.

Su, M. S., Shyu, Y. T., Chein, P. J. (2008). Antioxidant activity of citrus herbal product extracts. Food Chem., 111(4), 892–896. https://doi.org/10.1016/j.foodchem.2008.05.002

Suchitra, K., Wanapat, M. (2008). Study on ruminal degradability of local plants by using nylon bag technique. Livest. Res. Rural Dev., 20 (Suppl.).

Pino, J. A., Agüero, J., Marbot, R., Fuentes, V. (2001). Leaf oil of *Psidium guajava* L. from Cuba. J. Essent. Oil Res., 13(1), 61–62. https://doi.org/10.1080/10412905.2001.9699607

Thomas, J. A. (1994). Oxidative stress, oxidative defense and dietary constituents. In: M. E. Shils, J. Olson (Eds.), Modern Nutrition in Health and Disease. 8th ed. (pp. 501–512). Philadelphia: Lee and Febiger.

Vadderzant, C., Splittsolesser, D. F. (Eds.) (2005). Methods for the microbial examination of food. 3rd Ed. Washington D.C: American Public Health Association.

Zayan, A. F. (2016). Production of functional Kareish cheese by using plant stabilizer. J. Food Dairy Sci., Mansoura Univ., 7(4), 265–272. https://doi.org/10.21608/JFDS.2016.42997

Zheng, W., Wang, S. Y. (2001). Antioxidant activity and phenolic compounds in selected herbs. J. Agric. Food Chem., 49(11), 5165–5170. https://doi.org/10.1021/jf010697n