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EFFECTIVENESS OF CARDAMOM (*ELETTARIA CARDAMOMUM*) OR BAY LEAF (*LAURUS NOBILIS* L.) POWDER IN IMPROVING THE QUALITY OF LABNEH

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ABSTRACT

Background. Herbs and spices are natural ingredients that have been widely used not just as food flavouring but also for their health attributes. The antioxidant, antimicrobial and anticancer components present in them enhance the health and medical status of human beings. The present study aims to produce Labneh fortified with cardamom and bay leaf powder to enhance the quality and shelf life.

Materials and methods. Cardamom or bay leaf powder were added separately at the ratios of 0.25, 0.50, 0.75 and 1% (w/w) to Labneh and the treatments were compared with a control without cardamom or bay leaf powder during storage (at 5 ±1°C for 40 days).

Results. The total solids, fat, ash, carbohydrate and fiber contents were insignificantly higher in Labneh containing cardamom or bay leaf powder than control. The titratable acidity of Labneh gradually increased, whereas the pH values decreased by increasing the concentration of cardamom or bay leaf powder during the storage period. No significant differences were found in any textural parameters between Labneh containing condiments and control, except for that containing 1% cardamom or bay leaf powder, which exhibited higher hardness during the storage period. Minerals, antioxidants activity (RSA%), total phenolic (TPC) and total flavonoids content (TFC) increased with the increase of the added percentage of cardamom or bay leaf powder compared to control. Due to the stimulatory effect of cardamom and bay leaves on Lactic acid bacteria (LAB), the viability of the total bacterial count (TBC) gradually increased as the level of those condiments increased. The control became moldy after 10 days of cold storage while Labneh containing condiments remained unspoiled with yeasts and moulds for up to 30 days of cold storage. Sensory evaluation indicated that 1% addition of cardamom and 0.75% of bay leaf powder to Labneh improved quality and extends the shelf life of Labneh up to 30 days at 5 ±1°C.

Conclusion. Labneh supplemented with cardamom or bay leaf powder can be considered as a novel product with acceptable quality and extended shelf life.

Keywords: bay leaves cardamom, Labneh, quality properties, sensory attributes, shelf life

INTRODUCTION

Herbs and spices, commonly known as aromatic plants, have been used by many civilizations around the world for their flavouring, medicinal, antioxidant and preservative properties (Souza et al., 2005). Their parts, for instance leaves, stems or seeds, can be used as such or can be dried and used later (Firenzuoli and Gori, 2007). Studies indicate the role of herbs, spices or condiments in prolonging the shelf life of foods due to their

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bacteriostatic or bactericidal activity and prevention in food rancidity due to their antioxidant activity (Shelef, 1984). Therefore, fortification of herbs or spices in dairy products could provide added value to functional dairy products with prolonged shelf-life.

In recent years, there have been growing interests in using natural antimicrobial compounds, especially those extracted from plants for the preservation of foods and dairy products, which leads to an increased shelf life of these products. In Egypt, many investigators used natural flavouring additives in dairy products as flavours and used for preservatives (antiviral, antibacterial and antifungal compounds) those such as aqueous cayenne pepper and marjoram extracts in Ultrafiltered cheese (Abd-Alla et al., 2000), tolue balsam extracts in Karish cheese (El-Nemer et al., 2003), twenty different essential oils and powder (such as black cumin, shallots, cardamom, bay leaf, capsicum… etc.) in manufacturing flavoured Tallaga cheese (Hussein, 2004) and essential oils of garlic, cumin, coriander, clove, dill and parsley added to Labneh (Ismail et al., 2006). The use of some spice powders improved the quality of goat's milk cheese (Hamid and Abdelrahman, 2012).

One of the most well-known plants from the *Lauraceae* family is *Laurus nobilis* L., which is also known as bay or laurel leaves. Bay is one of the most frequently used cooking spices for flavouring meat products, fish and soups (Ivanović et al., 2010; Marzouki et al., 2009).

Traditionally, the dry bay leaves and their infusions are used to treat digestive difficulties as epigastric pain, flatulence, bloating and eructation problems. Leaves and fruits of bay plant have been used as astringent, diaphoretic, stimulative and emetic as well as emmenagogue, abortifacient and insect repellent. In addition, as it is an aromatic plant, its essential oil is added in cosmetic products such as soaps, creams and perfumes (Kaurinovic et al., 2010). Phytochemical studies on bay leaves and its fruits have indicated various secondary metabolites including alkaloids, flavonols (kaempferol, myricetin and quercitin), flavones (apigenin and luteolin), glycosylated flavonoids, sesquiterpene lactones, monoterpene and germacrane alcohols (Fukuyama et al., 2011; Škerget et al., 2005). In addition, the potential antioxidant effect of bay leaves extract has been reported. The methanolic extract of seed oil exhibited antioxidant properties in both 2,2-diphenyl-l-picrylhydrazl (DPPH) free radical scavenging and β-carotene/linoleic acid test systems (Ozcan et al., 2010). In another study, the antioxidant possibility of ethanolic and aqueous extracts of *Hypericum perforatum*, *Ocimum basilicum* and *L. nobilis* leaves were assessed by DPPH assay. The aqueous extract of *L. nobilis* showed the lowest radical scavenging capacity (RSC) as compared to *H. perforatum* and *O. basilicum*. However, the ethanolic extracts of *L. nobilis* showed a greater DPPH radical scavenging effect than their aqueous extracts (Rukhkyan et al., 2013). The bay leaves and their isolated flavonoids and glycosides reduced TC, TG, LDL-C and VLDL-C. Therefore bay leaf is a useful agent in reducing hyperlipidemia (AL-Samarrai et al., 2017).

Cardamom (*Elettaria cardamomum*) is used in flavoured sweets, baked goods, tea and coffee. It is also used as food preservative owing to its antibacterial and antioxidant properties (Govindarajan et al., 1982).

In additional, the antimicrobial and antioxidant properties of cardamom, among others, leads to a research area on their use as preservatives in food. Cardamom used in foods such as meats have a high possibility of success and potential antimicrobial activity that is comparable with the effect of preservatives based on nitrites used nowadays, which have been claimed to cause negative health effects, making it possible to research a way to substitute chemical based preservatives with natural based ones for food preservation and also food preparations containing synthetic antibacterial and chemical preservatives (e.g. sorbic acid and benzoic acid) which are restricted in many countries (Singh et al., 2018).

Labneh (concentrated yoghurt) is a popular dairy product obtained by partial drainage of yoghurt and has a different composition and properties according to the kind of milk used. It has smooth texture, soft and spreadable with clean acid flavor (Mohamed et al., 2013). Like other milk products, Labneh can undergo spoilage by the growth and activity of spoilage microorganisms. The shelf life of traditional Labneh is short, even at low temperatures. This may be due

to the use of unsanitary cloth bags and unhygienic processing of the product, which rises from microbial contamination (El-Samragy, 1997). Subsequently, the high microbial load of Labneh, combined with unfavorable storage conditions, results in the formation of off-flavours and physicochemical defects that finally lead to rejection of Labneh. Sorbaets and benzoates have been widely used to control spoilage and to extend the shelf life of Labneh (Mihyar et al., 1999).

One of the most acceptable ways to increase the shelf life of perishable food products is using herbs and spices as bio-preservatives (Burt, 2004). Considering the previous aspects, the objective of this investigation was to enhance the nutritional value and improve the quality of Labneh as a functional food through the addition of different concentrations of cardamom or bay leaf powder. The present study was designed to evaluate the effectiveness of cardamom or bay leaf powder in improving the quality and extending the shelf life of Labneh.

MATERIALS AND METHODS

Materials

Fresh cows' milk (3.50% fat, 4.55% protein, 13.10% total solids and pH 6.55) was obtained from the Faculty of Agriculture, Cairo, University, Giza, Egypt. Starter bacteria: Freeze dried starter culture (FD-DVS YC-X11-Yo-Flex) containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (1:1) was obtained from Chr. Hansen's Laboratories, Copenhagen, Denmark. Dry coarse commercial food grade salt was obtained from El-Nasr Saline's Company, Egypt. Folin-Ciocalteu's phenol reagent and gallic acid monohydrate were purchased from Fluka (Madrid, Spain), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) was obtained from Sigma-Aldrich (Germany). Bay leaf (*Laurus nobilis* L.) and Cardamom (*Elettaria cardamomum*) were obtained from local market. Fresh bay leaf and cardamom were washed carefully under running water, followed by distilled water, chopped into small pieces (~0.5 cm radius), oven-dried at 55–60°C for 48 hrs, and stored in air-tight plastic containers at 24°C in a dark place until used.

Methods

Preparation of cardamom and bay leaves powdered. Raw cardamom or bay leaves were powdered by milling in a laboratory mill type (National, Japan), then the crushed portion was sieved through a 0.1 mm mesh sieve. The resultant powder was packed in polyethylene bags and stored at 5 ±1°C in a refrigerator until used. The composition of cardamom or bay leaf powder used in Labneh are presented in Table 1.

Table 1. Composition of cardamom or bay leaf powder used in preparation of Labneh

Parameters, %		Cardamom	Bay leaves
Total solids (TS)		91.61 ±0.14	94.57 ±0.17
Fat		0.4 ±0.06	8.36 ±0.11
Protein		10.8 ±0.24	7.61 ±0.14
Carbohydrates*		75.91 ±0.28	75 ±0.06
Ash		4.5 ±0.25	3.6 ±0.20
Fiber		28 ±0.20	26.3 ±0.33
Minerals, mg/100 g	K	1 119	529
	Na	18	23
	Fe	14	43
	Zn	7.5	3.7
	Ca	383	834
	Mg	229	120
	P	178	113
	Mn	28	8.2

*Calculated by difference = 100 – (protein + ash + fat + moisture).
Values are means of three replicates ±SD.

Manufacturing of Labneh. Fresh cow milk was heated to 90°C for 15 min, cooled to 45°C and 3% of yoghurt starter (containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus* (1:1)) was added to the milk followed by mixing.

The cardamom concentrations (0.25, 0.50, 0.75 and 1% w/w) or bay leaves concentrations (0.25, 0.50, 0.75 and 1% w/w) powdered were incorporated into inoculated milk followed by mixing according to El-Sayed et al. (2017). Finally, all treatments were incubated at 40°C until full coagulation (after 3 hrs and pH 4.8). The resultant coagulants were mixed with 0.5% NaCl, transferred to the cheese cloth bags, and were hung in the refrigerator at 5 ±1°C for 16 h, to allow whey drainage. The fresh Labneh from each treatment was divided and placed into small plastic containers (50 g), capped and stored at 5 ±1°C for 40 days. Samples were taken on days 1, 10, 20, 30 and 40 for physiochemical, antioxidant, microbial and sensorial properties. All experiments and analyses were carried out in triplicate.

Analytical methods

Microbiological analysis. Total bacterial count for Labneh samples were done using plate count agar media according to the method described by APHA (2004). Detection and enumeration of yeasts and moulds were carried out according to Marshall (1992), using acidified potato dextrose agar (pH 3.5) using sterile lactic acid solution (10% conc.). All results were expressed as $\log_{10}$ colony forming unit (log cfu/g) for sample. The detection of coliform group was done according to the method suggested by BSI (1993) using violet red bile agar (VRBA).

Physiochemical analysis. The total solids, protein, fat, fiber, ash contents and titratable acidity (% lactic acid) in the Labneh samples were determined as described in AOAC (2007). Total carbohydrates were calculated by differences as described by James (1995). The pH values were measured by a digital laboratory pH meter (HI 93 1400, Hanna instruments). Mineral contents were determined as described by Hankinson (1975) using an atomic absorption spectrophotometer, NO.3300 (PerkinElmer, US instrument Division Norwalk, CT, USA).

Antioxidant activity as an indicator of antioxidant contents was determined according to Olivera et al. (2006). The total phenolics (TPC) were determined with the Folin-Ciocalteu reagent as described by Maurya and Singh (2010), gallic acid was applied as a standard and the results were expressed as mg gallic acid equivalent (GAE). Total flavonoids contents (TFC) were determined according to the method of Olajire and Azeez (2011), the total flavonoid content was calculated from a calibration curve and the result was expressed as mg of quercetin equivalent (QE).

Texture profile analysis. Texture profile measurements of Labneh samples were done as described by Lobato-Calleros et al. (1997) using a Universal Testing Machine (TMS-Pro), Food Technology Corporation, Sterling, Virginia, USA, equipped with a (250 lbf) load cell and connected to a computer programmed with Texture Pro™ texture analysis software (program, DEV TPA with hold). The texture profile parameters were hardness, cohesiveness, gumminess, chewiness, adhesiveness and springiness.

Organoleptic properties. The Labneh samples were sensory evaluated using the scheme of Salem et al. (2007) by ten panelists of staff members from the Food Technology Research Institute for flavour (50 points), body and texture (40 points), and appearance (10 points) on the 1st, 10th, 20th, 30th and 40th days of cold storage at 5 ±1°C.

Statistical analysis

All experimental data were expressed in mean values. Statistical analysis carried out using one-way analysis of variance (ANOVA) followed by Duncan's Multiple Range Test. The significance differences were defined at $P \leq 0.05$ using SAS program (SAS, 2001).

RESULTS AND DISCUSSION

Chemical properties of Labneh containing cardamom or bay leaves powdered. The total solids (TS), fat, ash and carbohydrate contents were insignificantly ($P \leq 0.05$) higher in cardamom and bay leaves powdered treatments than control sample (Table 2). Moreover, the values of these compounds were slightly increased by increasing the ratio of cardamom or bay leaf powder and during storage period. Our results are in harmony with those given by Derwich et al. (2011). Al-Otaibi and El-Demerdash (2008) found no noticeable differences in total solids, fat, protein, ash and carbohydrate of Labneh produced by the addition of

Table 2. Chemical properties of Labneh containing different ratios of cardamom or bay leaf powder

Component, %	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
TS	23.30^{a}	23.40^{a}	23.48^{a}	23.68^{a}	23.81^{a}	23.38^{a}	23.46^{a}	23.65^{a}	23.77^{a}
Fat	7.40^{a}	7.42^{a}	7.44^{a}	7.45^{a}	7.47^{a}	7.46^{a}	7.48^{a}	7.50^{a}	7.51^{a}
Protein	11.70^{a}	11.71^{a}	11.72^{a}	11.73^{a}	11.74^{a}	11.67^{a}	11.68^{a}	11.69^{a}	11.70^{a}
Ash	1.450^{a}	1.499^{a}	1.530^{a}	1.690^{a}	1.780^{a}	1.480^{a}	1.510^{a}	1.660^{a}	1.750^{a}
Carbohydrate*	2.75^{a}	2.77^{a}	2.79^{a}	2.81^{a}	2.82^{a}	2.77^{a}	2.79^{a}	2.80^{a}	2.81^{a}
Fiber	0.010^{d}	10.00^{c}	13.00^{bc}	17.00^{b}	21.00^{a}	8.50^{c}	12.60^{bc}	16.20^{b}	20.50^{a}

Means followed by the same lower case in each row indicate no significant ($P \leq 0.05$) effect of treatment.
*Calculated by difference = 100 – (protein + ash + fat + moisture).
Control – Labneh without cardamom or bay leaves powdered.
0.25 – Labneh with 0.25% cardamom or 0.25% bay leaves powdered.
0.50 – Labneh with 0.50% cardamom or 0.50% bay leaves powdered.
0.75 – Labneh with 0.75% cardamom or 0.75% bay leaves powdered.
1 – Labneh with 1% cardamom or 1% bay leaves powdered.

a different ratio of herbs and spices in agreement with the present results. Also, Shamsia (2016) found no differences in fat/dry matter (F/DM) and TS of Labneh supplemented with five different moringa oliefera. The slight increase of both TS and F/DM during storage may be due to the loss of moisture (Chakraborty et al., 2017; Thabet et al., 2014).

The differences in fiber (Table 2) of Labneh from the different treatments can be attributed to enhanced starter activity of Labneh containing cardamom or bay leaves powdered. Also, fiber content increased by increasing the ratio of cardamom or bay leaf powder and during storage period (data not shown) in all treatments. These results were in the same line with these obtained by Abou Ayana and Gamal El Deen (2011).

pH values and titratable acidity (%) of Labneh containing cardamom or bay leaves powdered. Values of pH and titratable acidity (TA) of Labneh samples during the cold storage period followed opposite trends are shown in Table 3. The titrable acidity values of the treated Labneh gradually increased, whereas

Table 3. Acidity and pH values of Labneh containing different ratios of cardamom or bay leaf powder during storage at 5 ±1°C*

Storage period days	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
1	2	3	4	5	6	7	8	9	10
		Acidity, % lactic acid							
Fresh	0.95^{Bb}	1.13^{Ba}	1.26^{Ba}	1.39^{Ba}	1.42^{Ba}	1.15^{Ba}	1.28^{Ba}	1.41^{Ba}	1.45^{Ba}
10	1.15^{Ab}	1.67^{Aab}	1.68^{Aab}	1.71^{ABab}	1.72^{ABab}	1.69^{Aab}	1.70^{ABab}	1.73^{ABab}	1.75^{Aa}
20	1.26^{Ab}	1.71^{Aab}	1.73^{Aab}	1.75^{Aab}	1.78^{Aab}	1.75^{Aab}	1.77^{Aab}	1.80^{Aa}	1.84^{Aa}

Table 3 – cont.

1	2	3	4	5	6	7	8	9	10
30	1.35^{Ab}	1.87^{Aab}	1.89^{Aab}	1.91^{Aa}	1.93^{Aa}	1.89^{Aab}	1.90^{Aab}	1.92^{Aa}	1.95^{Aa}
40	1.45^{Ab}	1.92^{Aab}	1.95^{Aab}	1.97^{Aab}	1.99^{Aab}	1.95^{Aab}	1.98^{Aab}	2.01^{Aa}	2.04^{Aa}
pH values									
Fresh	4.67^{Aa}	4.20^{Aa}	4.14^{Aa}	4.08^{Aa}	4.02^{Aa}	4.18^{Aa}	4.12^{Aa}	4.06^{Aa}	4.01^{Aa}
10	4.60^{Aa}	4.05^{Aa}	4.03^{Aa}	3.96^{ABa}	3.90^{ABa}	4.03^{Aa}	4.01^{Aa}	3.94^{ABa}	3.87^{ABa}
20	4.56^{Aa}	3.93^{ABa}	3.87^{Aba}	3.73^{ABa}	3.69^{Ba}	3.97^{ABa}	3.83^{ABa}	3.68^{Ba}	3.63^{Ba}
30	4.52^{Aa}	3.81^{ABa}	3.71^{Aba}	3.60^{Ba}	3.53^{Bb}	3.83^{ABa}	3.70^{ABa}	3.59^{Bb}	3.51^{Bb}
40	4.49^{Aa}	3.75^{ABa}	3.61^{Ba}	3.47^{Bb}	3.44^{Bb}	3.78^{ABa}	3.58^{Bb}	3.43^{Bb}	3.39^{Bb}

Means followed by the same lower case in each row indicate no significant ($P \leq 0.05$) effect of treatment.
Means followed by the same upper case in the same column indicate no significant ($P \leq 0.05$) effect of storage.
*See foot note Table 2.

Table 4. Texture characteristics of Labneh containing different ratios of cardamom or bay leaf powder during storage at 5 ±1°C*

Texture characteristics	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
Fresh									
Hardness,	5.0^{Bb}	5.2^{Bb}	6.0^{Aab}	7.0^{Aa}	7.8^{Aa}	5.1^{Bb}	5.8^{Bb}	6.6^{Aab}	7.5^{Aa}
Adhesiveness, mj	4.1^{Aa}	4.3^{Aa}	4.5^{Aa}	4.7^{Aa}	4.9^{Aa}	4.3^{Aa}	4.4^{Aa}	4.5^{Aa}	4.8^{Aa}
Cohesiveness, ratio	0.52^{Aa}	0.55^{Aa}	0.52^{Aa}	0.49^{Aab}	0.46^{Aab}	0.54^{Aa}	0.52^{Aa}	0.48^{Aab}	0.44^{Aab}
Springiness, mm	4.80^{Aa}	4.60^{Aa}	4.40^{Aa}	4.30^{Aa}	4.20^{Aa}	4.59^{Aa}	4.40^{Aa}	4.29^{Aa}	4.20^{Aa}
Gumminess, N	2.6^{Aab}	2.86^{Aab}	3.12^{Aa}	3.43^{Aa}	3.59^{Aa}	2.75^{Aab}	3.02^{Aa}	3.17^{Aa}	3.3^{Aa}
Chewiness, N/mm	12.48^{Aab}	13.16^{Aa}	13.73^{Aa}	14.75^{Aa}	15.07^{Aa}	12.64^{Aab}	13.27^{Aa}	13.59^{Aa}	13.86^{Aa}
40 days									
Hardness, N	6.0^{Bb}	7.0^{Aab}	7.8^{Aab}	8.8^{Aa}	9.0^{Aa}	6.2^{Bb}	6.8^{Ba}	7.8^{Aab}	8.8^{Aa}
Adhesiveness, mJ	4.0^{Aa}	4.1^{Aa}	4.3^{Aa}	4.5^{Aa}	4.6^{Aa}	4.0^{Aa}	4.2^{Aa}	4.3^{Aa}	4.5^{Aa}
Cohesiveness, ratio	0.55^{Aa}	0.58^{Aa}	0.55^{Aa}	0.52^{Aab}	0.52^{Aab}	0.57^{Aa}	0.56^{Aa}	0.51^{Aab}	0.49^{Aab}
Springiness, mm	4.50^{Aa}	4.45^{Aa}	4.30^{Aa}	4.20^{Aa}	4.15^{Aa}	4.45^{Aa}	4.30^{Aa}	4.19^{Aa}	4.08^{Aa}
Gumminess, N	3.3^{Aab}	4.06^{Aab}	4.29^{Aa}	4.57^{Aa}	4.68^{Aa}	3.53^{Aab}	3.80^{Aab}	3.97^{Aab}	4.31^{Aa}
Chewiness, N/mm	14.85^{Aab}	18.07^{Aa}	18.45^{Aa}	19.22^{Aa}	19.42^{Aa}	15.73^{Aa}	16.37^{Aa}	16.67^{Aa}	17.60^{Aa}

Means followed by the same lower case in each row indicate no significant ($P \leq 0.05$) effect of treatment.
Means followed by the same upper case in the same column indicate no significant ($P \leq 0.05$) effect of storage.
*See foot note Table 2.

the pH values decreased in all samples as a result of the starter growth and activity. Such findings are in agreement with those in Kumar et al. (2008), Ismail et al. (2017) and Tawfek et al. (2018) for pH and acidity changes in Labneh.

Inclusion of cardamom or bay leaf powder insignificantly increased the acidity and decreased the pH of Labneh. On the other hand, significant ($P \leq 0.05$) increases in acidity and decreases in pH were apparent during storage.

The highest values of acidity and lowest value of pH were obtained with Labneh containing 1% cardamom or bay leaf powder throughout cold storage. The present result suggests that the addition of cardamom or bay leaves powdered enhanced the growth of starter culture bacteria. The present findings are in agreement with the studies of Gokhale et al. (2016), Yangilar and Yildiz (2017), El-Sayed et al. (2017) and Al-Otaibi and El-Demerdash (2008) who suggested that the essential oils had a stimulatory effect on the growth and activity of starter culture and its viable counts in yoghurt and Labneh products.

Textural properties of Labneh containing cardamom or bay leaf powder. Table 4 shows significant differences ($P \leq 0.05$) in the hardness values of Labneh were the lowest values compared with those found in the control sample and increased gradually by increasing the ratios of added cardamom or bay leaf powder. These observations could be related to the increased TS content of Labneh containing cardamom or bay leaf powder with the highest value in the 1% from both and the highest hardness. Also, the high acidity and low pH may contribute to the hardness of Labneh. Thomas (1970) mentioned that with low pH, the cheese protein aggregates which causes increased firmness of cheese. In addition, Awad et al. (2002) reported that by decreasing the pH of block-processed cheese, the hardness increased. As shown in Table 4 gumminess increased significantly ($P \leq 0.05$), while changes in chewiness were not significant with the increase of the added cardamom or bay leaf powder. On the other hand, the less significant high springiness and significantly high cohesiveness values were recorded in control sample (Tawfek et al., 2018).

Mineral contents (mg/kg) of Labneh containing cardamom or bay leaves powdered. The impact of the used cardamom or bay leaf powder (Table 5) on the minerals content of the prepared products was expected of the current study. The total amount of minerals is generally presented as total ash and in case of cardamom and bay leaf powder this value ranged between 1.400–1.800 percent in cardamom or bay leaf powder. Fluctuations in mineral levels may be due to the differences in feeding and water intake. Milk and milk products are considered poor sources of Fe and therefore fortification of milk products with natural a Fe source would be a helpful tool. From the obtained results in Table 5 it was noticed that the iron content of fortified Labneh with cardamom or bay leaf powder varied between 14.86–34.14 mg/kg with cardamom and 16.28–62.85 mg/kg with bay leaf powder compared to 10.22 mg/kg in control. These results are in agreement with those reported by El-Sayed and Youssef (2019) who stated that adding cardamom or bay leaf powder to Labneh increased iron content. Adding cardamom or bay leaf powder to Labneh blends was also accompanied by a high potassium (K) content due to the high content of this element in cardamom (1119 mg/100 g) and bay leaf powder (529 mg/100 g; Table 1). The addition of cardamom or bay leaf powder to Labneh slightly increased zinc (Z), sodium (Na), calcium (Ca), phosphor (P), magnesium (Mg) and manganese (Mn) contents of resultant Labneh.

Effect of cardamom or bay leaf powder on antioxidant activity, phenolic and flavonoids compounds of Labneh. Data in Table 6 indicated that supplementing the resultant Labneh with condiments greatly increased the antioxidant activity (RSA%) with increasing concentration compared with control and there were significant differences between the treatments and the control. Labneh made with bay leaves gained a higher RSA (%) and treatment with 1% bay leaves powdered had the highest value (44.25%), while control had the lowest value (20.19%). This could be associated with high bioactive compounds released in supplemented Labneh with antioxidant properties. A similar trend was reported by Fakhr El-Din et al. (2017) and Felfoul et al. (2017). Likewise, the antioxidant activity (RSA) significantly decreased ($P \leq 0.05$) in all Labneh treatments over the storage period,

Table 5. Mineral contents (mg/kg) of Labneh containing different ratios (%) of cardamom or bay leaf powder*

Minerals mg/kg	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
Sodium (Na)	1 145.01	1 259.12	1 513.58	1 540.14	1 626.25	1 430.05	1 626.85	1 655.79	1 724.42
Potassium (K)	2 770.69	7 019.79	17 978.92	43 508.95	53 097.21	21 185.44	25 590.52	85 512.56	119 737.59
Calcium (Ca)	1 542.68	1 580.36	1 724.64	1 805.60	2 097.91	2 218.24	2 456.99	2 641.7	2 882.30
Phosphor (P)	103.06	109.63	115.91	121.11	125.93	119.20	124.35	128.45	132.55
Magnesium (Mg)	167.33	171.86	239.73	337.84	353.96	307.49	491.10	524.54	748.69
Iron (Fe)	10.22	14.86	21.60	29.61	34.14	16.28	50.03	50.31	62.85
Zinc (Zn)	274.40	320.30	345.78	397.01	436.31	342.56	386.63	414.74	452.83
Manganese (Mn)	8.83	26.71	32.50	58.19	88.26	29.04	98.17	99.87	136.10

*See foot note Table 2.

Table 6. Antioxidant activity, total phenols and flavonoids compounds of Labneh containing different ratios (%) of cardamom or bay leaf powder during storage at 5 ±1°C*

Parameter(s)	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
Fresh									
Antioxidant activity, RSA%	20.19^{Bc}	30.15^{Ab}	34.66^{Aab}	36.31^{Aab}	41.25^{Aa}	33.18^{Aab}	37.44^{Aab}	41.78^{Aa}	44.25^{Aa}
Total phenols, mg GAE/100 g	15.86^{Bb}	26.59^{Aa}	27.36^{Aa}	28.54^{Aa}	29.62^{Aa}	27.33^{Aa}	27.67^{Aa}	29.89^{Aa}	31.22^{Aa}
Total flavonoids, mg QE/100 g	2.61^{Bb}	5.19^{Aa}	5.29^{Aa}	6.33^{Aa}	7.74^{Aa}	5.83^{Aa}	6.27^{Aa}	7.13^{Aa}	8.04^{Aa}
40 days									
Antioxidant activity, RSA%	16.25^{Cd}	23.17^{Bc}	30.14^{Bab}	32.33^{Bab}	36.45^{Ba}	28.56^{Bab}	31.74^{Bab}	36.14^{Ba}	39.47^{Ba}
Total phenols, mg GAE/100 g	11.55^{Cb}	18.64^{Ba}	19.19^{Ba}	21.57^{Ba}	23.85^{Ba}	19.75^{Ba}	20.45^{Ba}	23.41^{Ba}	25.08^{Ba}
Total flavonoids, mg QE/100 g	1.87^{Cb}	4.12^{Ba}	4.85^{Ba}	5.23^{Ba}	6.05^{Ba}	4.78^{Ba}	5.47^{Ba}	6.05^{Ba}	6.8^{Ba}

Means followed by the same lower case in each row indicate no significant ($P \leq 0.05$) effect of treatment.
Means followed by the same upper case in the same column indicate no significant ($P \leq 0.05$) effect of storage.
RSA – radical scavenging activity, GAE – gallic acid equivalent, QE – Querciten equivalent.
*See foot note Table 2.

being lower in control rather than the supplemented Labneh treatments. Also, additional cardamom or bay leaf powder in Labneh led to an increase in the total phenolic (TPC) and total flavonoids content (TFC), so condiments enriched Labneh exhibited a higher and statistically significant increase in the TPC and TFC than when compared with the control. Total phenolic – TPC and TFC were slightly higher in Labneh treated

with bay leaves than cardamom due to the high levels of phenolic and flavonoids compounds. By prolonging the storage period, the contents of TPC and TFC were proportionally reduced in all treatments. These decreases throughout the storage period may be related to the transformation of these compounds which decreased stability. The TPC and TFC have redox properties, which act as hydrogen donors and singlet oxygen quenchers. These results are confirmed by Chauhan et al. (2014) and Balabanova et al. (2020).

Effect of cardamom or bay leaves powdered on viability counts of Labneh. The total bacterial count (TBC) increased in the presence of cardamom or bay leaf powder compared with the control (Table 7). Nevertheless, the count was gradually influenced as the level of condiments increased. These results might be due to the stimulatory effect of cardamom or bay leaves on lactic acid bacteria (LAB) by enhancing their growth (Kozłowska et al., 2015). On the other hand, TBC remained higher for 10 days of cold storage

Table 7. Microbiological properties (log cfu/g) of Labneh containing different ratios (%) of cardamom or bay leaf powder during storage at 5 ±1°C*

Storage period days	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
Total bacterial count (TBC)									
Fresh	7.08^{Aa}	7.19^{Aa}	7.21^{Bb}	7.24^{Bb}	7.26^{Bb}	7.13^{Aa}	7.18^{Aa}	7.21^{Bb}	7.24^{Bb}
10	7.17^{Ab}	7.28^{Aab}	7.30^{Aab}	7.31^{Aa}	7.33^{Aa}	7.25^{Aab}	7.25^{Aab}	7.28^{Aab}	7.30^{Aab}
20	7.09^{ABb}	7.18^{Ab}	7.21^{Ab}	7.20^{Ab}	7.25^{BCa}	7.15^{Ab}	7.16^{Ab}	7.22^{Ab}	7.26^{BCa}
30	7.05^{ABb}	7.09^{Ab}	7.10^{Ab}	7.18^{Ab}	7.21^{BCa}	7.06^{Ab}	7.08^{Ab}	7.17^{Ab}	7.20^{BCa}
40	6.90^{Bb}	6.98^{Bb}	6.99^{Bab}	7.13^{Ca}	7.16^{Ba}	6.96^{Bb}	6.97^{Bb}	7.10^{Ca}	7.12^{Ba}
Yeast and mould counts									
Fresh	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	ND	ND	ND	ND	ND	ND	ND	ND	ND
20	2.70^{A}	ND	ND	ND	ND	ND	ND	ND	ND
30	3.04^{B}	ND	ND	ND	ND	ND	ND	ND	ND
40	3.45^{B}	2.85^{A}	2.60^{A}	2.48^{A}	2.48^{A}	3.08^{B}	2.90^{A}	2.70^{A}	2.60^{A}
Coliforms									
Fresh	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	ND	ND	ND	ND	ND	ND	ND	ND	ND
20	ND	ND	ND	ND	ND	ND	ND	ND	ND
30	ND	ND	ND	ND	ND	ND	ND	ND	ND
40	ND	ND	ND	ND	ND	ND	ND	ND	ND

*See foot note Table 2.
Means followed by the same lower case in each row indicate no significant ($P \leq 0.05$) effect of treatment.
Means followed by the same upper case in the same column indicate no significant ($P \leq 0.05$) effect of storage.
ND – not detected.

and then started to decline up to the end of storage (40 days). The higher counts during storage period (10 days) could be attributed to the protease from condiments capable of degrading protein, which could have provided the essential growth factors in a form of peptides and amino acids to improve the growth of bacteria. These results were in agreement with that of Abd El-Aziz et al. (2012) and Ahmed et al. (2013). The decline of total bacterial count at the end of the storage period are probably due to the sensitivity of the starter culture and to the increased acidity in Labneh and secretion of some other metabolites, which reduced the counts of bacteria (El-Alfy et al., 2010).

Yeast and mould counts were not detected in any Labneh treatments either when fresh or after stored at 5 ±1°C, with exception of control, which had an account (2.70 log cfu/g) after 20 days. This is due to the inhibition of yeasts and mould growth that may be caused by the natural compounds, which possess antimicrobial and antifungal activity, i.e. beta-carotene, total phenols and total flavonoids that are present in added condiments (Algarni, 2016; Al-Otaibi and El-Demerdash, 2008; Balabanova et al., 2020). Meanwhile, at the end of storage (40 days), yeasts and moulds appeared in all Labneh treatments.

Coliforms were examined and not detected in any of the Labneh treatments. This absence is a leading indicator of high quality and high hygiene conditions during the production and storage of Labneh.

The obtained results of yeasts and moulds, acidity and total bacterial count in Labneh supplemented with cardamom or bay leaves powdered cleared the effectiveness of those condiments in extending the shelf life of Labneh.

Sensory attributes of Labneh supplemented with cardamom or bay leaves powdered. All samples got similar scores for acceptability when fresh, and no significant $P \leq 0.05$ differences were found between treatments and the control. Table 8 showed the main effect of cardamom or bay leaf powder on sensory attributes of Labneh. Cardamom or bay leaf powder had no

Table 8. Sensory attributes of Labneh containing different ratios (%) of cardamom and bay leaves powdered during storage at 5 ±1°C*

Storage period days	Control Nil	Level of treatments, %							
		cardamom				bay leaves			
		0.25	0.50	0.75	1	0.25	0.50	0.75	1
1	2	3	4	5	6	7	8	9	10
					Flavour (50)				
Fresh	48.50^{Aa}	49.00^{Aa}	49.00^{Aa}	49.50^{Aa}	50.00^{Aa}	48.50^{Aa}	49.50^{Aa}	49.50^{Aa}	40.00^{Bb}
10	47.00^{Aa}	49.20^{Aa}	49.50^{Aa}	49.80^{Aa}	50.00^{Aa}	49.00^{Aa}	49.55^{Aa}	49.60^{Aa}	40.00^{Bb}
20	ND	49.50^{Aa}	50.00^{Aa}	50.00^{Aa}	50.00^{Aa}	49.50^{Aa}	49.60^{Aa}	50.00^{Aa}	40.00^{Bb}
30	ND	50.00^{Aa}	50.00^{Aa}	50.00^{Aa}	50.00^{Aa}	49.80^{Aa}	50.00^{Aa}	50.00^{Aa}	40.00^{Bb}
40	ND	ND	ND	ND	ND	ND	ND	ND	ND
					Body and texture (40)				
Fresh	39.50^{Aa}	39.55^{Aa}	39.60^{Aa}	39.80^{Aa}	40.00^{Aa}	39.50^{Aa}	39.60^{Aa}	39.65^{Aa}	35.50^{Bb}
10	39.00^{Aa}	39.60^{Aa}	39.70^{Aa}	39.99^{Aa}	40.00^{Aa}	39.60^{Aa}	39.70^{Aa}	39.70^{Aa}	35.60^{Bb}
20	ND	39.70^{Aa}	39.90^{Aa}	40.00^{Aa}	40.00^{Aa}	39.70^{Aa}	39.80^{Aa}	39.85^{Aa}	36.00^{Ba}
30	ND	39.90^{Aa}	40.00^{Aa}	40.00^{Aa}	40.00^{Aa}	39.85^{Aa}	39.90^{Aa}	39.95^{Aa}	36.50^{Ba}
40	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 8 – cont.

1	2	3	4	5	6	7	8	9	10
					Appearance (10)				
Fresh	9.65^{Aa}	9.70^{Aa}	9.80^{Aa}	9.90^{Aa}	10.00^{Aa}	9.50^{Aa}	9.65^{Aa}	9.80^{Aa}	6.50^{Bb}
10	9.60^{Aa}	9.80^{Aa}	9.90^{Aa}	10.00^{Aa}	10.00^{Aa}	9.50^{Aa}	9.70^{Aa}	9.90^{Aa}	6.50^{Bb}
20	ND	9.80^{Aa}	9.90^{Aa}	10.00^{Aa}	10.00^{Aa}	9.50^{Aa}	9.70^{Aa}	9.90^{Aa}	6.50^{Bb}
30	ND	9.90^{Aa}	9.90^{Aa}	10.00^{Aa}	10.00^{Aa}	9.50^{Aa}	9.70^{Aa}	9.90^{Aa}	6.50^{Bb}
40	ND	ND	ND	ND	ND	ND	ND	ND	ND
					Total score (100)				
Fresh	97.65^{Aa}	98.25^{Aa}	98.40^{Aa}	99.20^{Aa}	100.00^{Aa}	97.50^{Aa}	98.75^{Aa}	98.95^{Aa}	82.00^{Bb}
10	95.60^{Aa}	98.60^{Aa}	99.10^{Aa}	99.79^{Aa}	100.00^{Aa}	98.10^{Aa}	98.95^{Aa}	99.20^{Aa}	82.10^{Bb}
20	ND	99.00^{Aa}	99.80^{Aa}	100.00^{Aa}	100.00^{Aa}	98.70^{Aa}	99.10^{Aa}	99.75^{Aa}	82.50^{Bb}
30	ND	99.80^{Aa}	99.90^{Aa}	100.00^{Aa}	100.00^{Aa}	99.15^{Aa}	99.60^{Aa}	99.85^{Aa}	83.00^{Bb}
40	ND	ND	ND	ND	ND	ND	ND	ND	ND

Means followed by the same lower case in each row indicate no significant ($P \leq 0.05$) effect of treatment.
Means followed by the same upper case in the same column indicate no significant ($P \leq 0.05$) effect of storage.
*See foot note Table 2.
ND – not determined.

significant ($P \leq 0.05$) effect on the flavour of the Labneh in any treatments and the lowest one was for the Labneh with 1% bay leaf powder and there was no change in cardamom Labneh flavour. The values of the body and texture increased significantly ($P \leq 0.05$) and the best body and texture scores was for the cardamom or bay leaf powdered Labneh while the lowest one was for the Labneh with 1% bay leaves powdered and control. The appearance of the Labneh was affected significantly ($P \leq 0.05$) by cardamom or bay leaf powder, the best value of the appearance was for control and the lowest one was for the Labneh with 1% bay leaves powdered and there was no change in cardamom Labneh appearance.

All samples of Labneh containing cardamom or bay leaf powder remained without any signs of yeasts and moulds up to the end storage period (40 days) obtained by Desale et al. (2009). It can also be seen that the total scores of enhanced Labneh decreased with the increase in the concentration of added cardamom or bay leaf powder, with significant differences in the scores between different treatments and the lower scores were given to that containing 1% bay leaf powder due to its noticeable bitter taste. The addition of cardamom (1%) or bay leaf powder up to 0.75% had no effect on the acceptability and organoleptic properties of Labneh during storage.

CONCLUSION

Cardamom or bay leaf powder can be used successfully in the manufacturing of Labneh. The addition of up to (1%) of cardamom, (0.75%) of bay leaf powder ratios to Labneh improves the physiochemical, microbiological and sensory properties and extend the shelf life of Labneh up to 30 days at 5 ±1°C.

REFERENCES

Abd-Alla, M. S., Atalla, K. M., Ghazi, I. M., Galal, I. A. (2000). Effect of some aqueous plant extracts on microbiological, chemical and organoleptic properties of ultrafiltered cheese. Ann. Agric. Sci., Ain Shams Univ., Cairo, 45(2), 409–420.

Abd El-Aziz, M., Mohamed, S. H. S., Seleet, F. L. (2012). Production and evaluation of soft cheese fortified with ginger extract as a functional dairy food. Pol. J. Food Nutr. Sci., 62(2), 77–83.

Abou Ayana, I. A. A., Gamal El Deen, A. A. (2011). Improvement of the properties of goat's milk Labneh using some aromatic and vegetable oils. Int. J. Dairy Sci., 6(2), 112–123. https://doi.org/10.3923/ijds.2011.112.123

Ahmed, S., Umar, H., Anjum, F. M., Murtaza, M. A. (2013). Quality evaluation of olive oil coated Labneh cheese mixed with culinary herbs. Buffalo Bull., 32(2), 1316–1323.

Algarni, E. H. A. (2016). Soft cheese supplemented with thyme, cumin and turmeric to increase shelf life during storage period. Adv. Environ. Biol., 10(12), 227–236.

Al-Otaibi, M., El-Demerdash, H. (2008). Improvement of the quality and shelf life of concentrated yoghurt (Labneh) by the addition of some essential oils. Afr. J. Microbiol. Res., 2(7),156–161.

AL-Samarrai, O. R., Naji, N. A., Hameed, R. R. (2017). Effect of bay leaf (*Laurus nobilis* L.) and its isolated (flavonoids and glycosides) on the lipids profile in the local Iraqi female rabbits. Tikrit J. Pure Sci., 22(6), 72–75.

AOAC (2007). Official methods of analysis (20th ed.) Gaithersburg, MD, USA: Association of Official Analytical Chemists.

APHA (2004). Standards methods for the examination of dairy products (17th ed.). Washington, DC, USA: American Public Health Association.

Awad, R. A., Abdel-Hamid, L. B., El-Shabrawy, S. A., Singh, R. K. (2002). Texture and microstructure of block type processed cheese with formulated emulsifying salt mixtures. LWT – Food Sci. Technol., 35(1), 54–61. https://doi.org/10.1006/fstl.2001.0828

Balabanova, T., Petkova, N., Ivanova, M., Panayotov, N. (2020). Design of Labneh cheese fortified with alginate encapsulated pepper (*Capsicum annuum*) extracts. Emir. J. Food Agric., 32(8), 559–566.

BSI (1993). Determination of *Enterobacteriaceae* in microbiological examination of food and animal feeding stuffs. BSI 5763. London, UK: British Standards Institution.

Burt, S. (2004). Essential oil: their antibacterial properties and potential application in foods – a review. Int. J. Food Microbiol., 94(3), 223–253. https://doi.org/10.1016/j.ijfoodmicro.2004.03.022

James, S. (ed., 1995). Analytical chemistry of foods. London: Chapman and Hall.

Chakraborty, C., Shramana, B., Sreemoyee, M., Kakali, B. (2017). Potential application of milk and milk production as carrier for herbs and spices. A review. Int. J. Eng. Res. Sci. Technol., 6(1), 114–125.

Chauhan, A. K., Singh, S., Singh, R. P., Kumar, A. (2014). Determination of antioxidant capacity, total phenolics and antimicrobial properties of spray-dried guava extract for value-added processing. J. Food Proc. Technol., 5(9), 368–377. http://dx.doi.org/10.4172/2157-7110.1000368

Derwich, E., Benziane, Z., Chabir, R. (2011). Aromatic and medicinal plants of Morocco: Chemical composition of essential oils of *Rosmarinus officinalis* and *Jumiperus phoemeea*. J. Appl. Biol. Pharm Technol., 2(1), 145–153.

Desale, R. J., Dhole, P. T., Deshmukh, A. R., Nimase, R. G. (2009). Studies on quality evaluation of market paneer. Asian J. Anim. Sci., 4(1), 73–74.

El-Alfy, M. B., Shenana, M. E., Ismail, E. A., Gafour, W. A., Roshdy, A. M. (2010). Improvement of non-traditional white soft cheese made from fresh milk fortified with adding skim milk powder and vegetable oils using different ratios of starter culture. Egypt. J. Appl. Sci., 25(10B), 495–518.

El-Nemer, T. M., Awad, S. A., Ali, A. H. (2003). Increasing of probiotic and therapeutic action in Karish cheese using toluene balsam extract. Egypt. J. Food Sci., 31(2), 213–226.

El-Samragy, Y. A. (1997). Labneh or yoghurt cheese: a review. Egypt. J. Dairy Sci., 25(2), 165–178.

El-Sayed, S. M., El-Sayed, H. S., Salama, H. H., Abo El-Nor, S. A. H. (2017). Improving the nutritional value and extending shelf life of Labneh by adding *Moringa oleifera* oil. Int. J. Dairy Sci., 12(2), 81–92.

El-Sayed, S. M., Youssef, A. M. (2019). Potential application of herbs and spices and their effects in functional dairy products. Heliyon Rev. Article, 5(6), 1–7. https://doi.org/10.1016/j.heliyon.2019.e01989

Fakhr El-Din, H. M., Gad, A. S., Haggag, H. F., Farahat, A. M., El-Said, M. M. (2017). Production of healthy fermented milk supplemented with natural sources of antioxidants. Int. J. Dairy Sci., 12(1), 52–63.

Felfoul, I., Borchani, M., Samet-Bali, O., Attia, H., Ayadi, M. A. (2017). Effect of ginger (*Zingiber officinalis*) addition on fermented bovine milk: Rheological properties, sensory attributes and antioxidant potential. J. New Sci., Agric. BioTech., 44(3), 2400–2409.

Firenzuoli, F., Gori, L. (2007). Herbal medicine today: clinical and research issues. Evid. Based Compl. Altern. Med., 4 (SI), 37–40 https://doi.org/10.1093/ecam/nem096

Fukuyama, N., Ino, C., Suzuki, Y., Kobayashi, N., Hamamoto, H., Sekimizu, K., Orihara, Y. (2011). Antimicrobial sesquiterpenoids from *Laurus nobilis* L. Nat. Prod. Res., 25(14), 1295–1303. https://doi.org/10.1080/14786419.2010.502532

Gokhale, A. J., Mallek, J., Patel, S. M., Patel, A. M., Pinto, S. (2016). Enhancement of shelf life of paneer by adopting hurdle technology. Int. J. Home Sci., 2(2), 303–308.

Govindarajan, V. S., Narasimhan, S., Raghuveer, K. G., Lewis, Y. S., Stahl, W. H. (1982). Cardamom: production, technology, chemistry, and quality. Crit. Rev. Food Sci. Nutr., 16(3), 229–326. https://doi.org/10.1080/10408398209527337

Hamid, O. I. A., Abdelrahman, N. A. M. (2012). Effect of adding cardamom, cinnamon and fenugreek to goat's milk curd on the quality of white cheese during storage. Int. J. Dairy Sci., 7(2), 43–50.

Hankinson, D. J. (1975). Potential source of copper contamination of farm milk supplies measured by atomic absorption spectrophotometer. J. Dairy Sci., 58(3), 326–336. https://doi.org/10.3168/jds.S0022-0302(75)84569-3

Hussein, G. A. M. (2004). Manufacture of flavoured Tallaga cheese. Proc. The 9th Egypt. Conf. Dairy Sci. Tech. "Milk and dairy products for a healthy future". Dokki, 9–11 October (2004), Cairo, Egypt.

Ismail, A. M., Harby, S., Salem, A. S. (2006). Production of flavoured Labneh with extended shelf life. Egypt. Dairy Sci., 34, 59–68.

Ismail, M. M., Ghoneem, G. A., El-Boraey, N. A., Tabekha, M. M., Elashrey, H. F. (2017). Manufacture of bio-Labneh using ABT culture and buffalo and soymilk mixtures. J. Microbiol., Biotechnol. Food Sci., 6(6), 1237–1245. https://doi.org/10.15414/jmbfs.2017.6.6.1237-1245

Ivanović, J., Mišić, D., Ristić, M., Pešić, O., Žižović, I. (2010). Supercritical CO_2 extract and essential oil of bay (*Laurus nobilis* L.) – chemical composition and antibacterial activity. J. Serb. Chem. Soc., 75(3), 395–404. https://doi.org/10.2298/JSC090303003I

Kaurinovic, B., Popovic, M., Vlaisavljevic, S. (2010). In vitro and in vivo effects of *Laurus nobilis* L. leaf extracts. Molecules, 15(5), 3378–3390. https://doi.org/10.3390/molecules15053378

Kozłowska, M., Ścibisz, L., Zaręba, D., Ziarno, M. (2015). Antioxidant properties and effect on lactic acid bacterial growth of spice extracts. CyTA – J. Food, 13(4), 573–577. https://doi.org/10.1080/19476337.2015.1022228

Kumar, S., Rai, D. C., Verma, D. N. (2008). Effect of fat levels on the physic-chemical and sensory attributes of buffalo milk paneer. Indian Vet. J., 85(11), 1182–1184.

Lobato-Calleros, C., Vernon-Carter, E. J., Guerrerolegarreta, I., Soriano-Santos, J., Escalona-Buendia, H. (1997). Use of fat blends in cheese analogs: influence on the sensory and instrumental textural characteristics. J. Texture Stud., 28(6), 619–632. https://doi.org/10.1111/j.1745-4603.1997.tb00142.x

Marshall, T. R. (1992). Standard methods for the examination of dairy products. Washington, DC: American Public Health Association.

Marzouki, H., Piras, A., Salah, K. B., Medini, H., Pivetta, T., Bouzid, S. (2009). Essential oil composition and variability of *Laurus nobilis* L. growing in Tunisia, comparison and chemometric investigation of different plant organs. Nat. Prod. Res., 23(4), 343–354. https://doi.org/10.1080/14786410802076200

Maurya, S., Singh, D. (2010). Quantitative analysis of total phenolic content in *Adhatoda vasica* Nees extracts. Int. J. Pharm. Tech. Res., 2(4), 2403–2406.

Mihyar, G. F., Yousif, A. K., Yamani, M. I. (1999). Determination of benzoic and sorbic acids in labneh by high performance liquid chromatography. J. Food Comp. Anal., 12(1), 53–61. https://doi.org/10.1006/jfca.1998.0804

Mohamed, S. H. S., Zaky, W. M., Kassem, J. M., Abbas, H. A., Salem, M. M. E., Said-Ahl, H. A. H. (2013). Impact of antimicrobial properties of some essential oils on cheese yoghurt quality. World Appl. Sci. J., 27(4), 497–507.

Olajire, A. A., Azeez, L. (2011).Total antioxidant activity, phenolic, flavonoid and ascorbic acid contents of Nigerian vegetables. Afr. J. Food Sci. Tech., 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. https://hrcak.srce.hr/5761

Ozcan, B., Esen, M., Sangun, M. K., Coleri, A., Caliskan, M. (2010). Effective antibacterial and antioxidant properties of methanolic extract of *Laurus nobilis* seed oil. J. Environ. Biol., 31(5), 637–641. http://www.jeb.co.in/

Rukhkyan, M., Tiratsuyan, S., Zilfyan, A., Vardapetyan, H. (2013). Wound healing activity of *Laurus nobilis* L. leaves extracts. Theor. Clin. Med., 16, 20–24.

Salem, M. M. E., Abd El-Gawad, M. A. M., Hassan, F. A. M., Effat, B. A. (2007). Use of synbiotics for production of functional low fat Labneh. Pol. J. Food Nutr. Sci., 57(2), 151–159.

SAS (2001). Statistical analysis system. SAS user's guide: Statistics. Cary, NC, USA: SAS Institute.

Shamsia, S. M. (2016). Production of Labneh fortified with *Moringa oliefera* as a new functional dairy product. Egypt. J. Dairy Sci., 44(2), 89–97.

Shelef, L. A. (1984). Antimicrobial effects of spices. J. Food Safety, 6(1), 29–44. https://doi.org/10.1111/j.1745-4565.1984.tb00477.x

Singh, R., Ravinder, K., Vipul, J. (2018). Antibacterial and antioxidant activity of green Cardamom and rosemary extract in food products: A brief review. Pharma Innov. J., 7(6), 568–573. http://www.thepharmajournal.com

Škerget, M., Kotnik, P., Hadolin, M., Hraš, A., Simonič, M., Knez, Ž. (2005). Phenols, proanthocyanidins, flavones

and flavonols in some plant materials and their antioxidant activities. Foods Chem., 89(2), 191–198. https://doi.org/10.1016/j.foodchem.2004.02.025

Souza, E. L., Stamford, T. L. M., Lima, E. O., Trajano, V. N., Filho, M. B. (2005). Antmicrobial effectiveness of spices. Brazilian. Archiv. Bio. Technol., 48(4), 549–558.

Tawfek, M. A., Farahat, E. S. A., Shalaby, S. M. (2018). Effectiveness of myrrh oil in improving the quality and shelf life of Labneh. Egypt. J. Dairy Sci., 46(1), 79–87.

Thabet, H. M., Nogaim, Q. A, Qasha, A. S., Abdoalaziz, O., Alnsheme, N. (2014). Evaluation of the effects of some plant derived essential oils on shelf life extension of Labneh. Merit. Res. J. Food Sci. Technol., 2(1), 8–14. http://www.meritresearchjournals.org/fst/index.htm

Thomas, M. A. (1970). Use of calcium co-precipitates in processed cheese. Aust. J. Dairy Technol., 25(1), 23–26.

Yangilar, F., Yildiz, P. O. (2017). Effects of using combined essential oils on quality parameters of bio-yoghurt. J. Food Process. Preserv., 42(1), e13332 https://doi.org/10.1111/jfpp.13332