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IMPROVING THE QUALITY AND SHELF LIFE OF PROBIOTICS LABNEH BY ADDING DRY LEAVES OF *MORINGA OLEIFERA* OR *MORINGA OLEIFERA* SEED OIL

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Abstract

Background and Objective: This study aimed to examine the impact of adding Moringa oleifera dry leaves and seed oil to labneh. Moringa leaves were incorporated at concentrations of 0.5-2%, and Moringa seed oil at 1-3%. Subsequence the chemical, microbiological and sensory properties of labneh were determined for 3 weeks at 6 + 1 °C. These results show that addition of *Moringa oleifera* dry leaves significantly increases total solids at all levels. Protein, carbohydrate, ash content, soluble nitrogen, titratable acidity, phenol content, total volatile acids, total bacterial, lactobacilli count, streptococci, bifidobacteria count, and proteolytic bacteria. Mold and yeast were not detected. Coliforms and psychrophiles are absent in laboratories fortified with *Moringa oleifera* seed oil. Total solids, fat, total phenolics, and total volatile fatty acids increased significantly, while protein, ash, titratable acidity, and carbohydrate content decreased without significant changes. Total bacterial count, Lactobacillus, Streptococcus, bifidobacteria counts increased with increasing lipid percentage, while lipolysis decreased. Mold and yeast were not detected in all labneh fortified with *Moringa oleifera* seed oil. Psyshrotrophic and coliform bacteria were absence from all labneh treatment until the end of storage. The scores showed that labneh fortified with 0.5% *Moringa oleifera* dry leaves and labneh fortified with 3% *Moringa oleifera* seed oil were more acceptable during storage. In summary, incorporating *Moringa oleifera* dried leaves or *Moringa oleifera* seed oil into labneh can result in a high-quality probiotic product with extended shelf life, functional benefits, and enhanced nutritional content.

Key words: Probiotics labneh, Moringa oleifera dry leaves, Moringa oleifera seed oil.

INTRODUCTION

Labneh is a traditional fermented dairy product produced in many countries in the Middle East. It is a condensed yoghurt that is traditionally made by straining full-fat yoghurt in a cloth bag (Hamad and Al-Sheikh, 1989 and Tamime and Robinson, 1978).

Labneh is classified as a yogurt cheese in the USDA Cheese Variety Description Manual (Anonymous, 1978). Traditionally, labneh is creamy white when made from fresh milk and pale yellow when made from reconstituted milk. The body and texture are homogeneously soft and smooth with no dryness or graininess. It spreads well without wheying off. The flavor should be clean and mildly acidic (Hamad and Al-Sheikh, 1989). Traditional methods are time consuming, require high levels of handling, and increase microbial contamination. As a result, traditionally prepared labneh usually has a short shelf life even when kept refrigerated (Tamime and Robinson, 1978).

Recently, the health benefits of Moringa oleifera dry leaves and Moringa oleifera seed oil, products have widely recognized all over the word, fortified labneh with Moringa oleifera can consider a new product with functional properties and extended the shelf life of this product (Salem et al., 2015).

Moringa leaves are rich in nutrients, with the dried leaves containing up to 30% digestible protein. The leaves are a source of sulfur-containing amino acids, such as methionine and cysteine, which are generally in short supply in most legumes (Martin et al., 1998) and contains high amounts of vitamin B-complex, calcium, potassium, iron and protein Hassan et al. (2016). Fuglie (2001) reported that Moringa leaves are so high in iron that a weighed Moringa leaf powder contains 14 times the iron of roast beef, one of the richest sources of iron. The iron content is also good and the leaves are said to be used in the Philippines to treat anemia (Fahey, 2005). Leaves are a great source of calcium (four times that of milk), protein (twice that of milk) and potassium (three times that of bananas) (Fuglie, 2001). In fact, the leaves of the Moringa tree have natural antioxidant properties such as ascorbic acid, flavonoids, phenols and carotenoids (Dillard and German, 2000). Moringa leaves are widely used to improve nutritional and sensory evaluation, adding its extracts to foods such as sauces, juices, spices, milk and bread leaves are used to improve nutritional and sensory properties (Mukunzi et al., 2011). Moringa seeds are rich in protein and oil. High oil yield, wide range of uses (Tarakci et al., 2011). In addition, it is of good quality, slow to sour, and has good antioxidant capacity. Flavonoids play an antioxidant role in the chelation process and have a defensive effect on cancer and heart disease. (Middleton et al., 2000). In addition, Moringa and its extracts have antibacterial activity against various pathogenic microorganisms such as Escherichia coli and Enterobacter. and Salmonella. Many researchers found that a major component found in this oil is unsaturated fatty acid (oleic acid), which adapted for use in pharmaceutical research (Abd-Ulkarim et al., 2005).

Moringa oil is composed of highly unsaturated fatty acids, of which polyunsaturated fatty acids account for 80.4%, mainly oleic acid 67.9%. Moringa oil has a low acid value and low free fatty acid composition, which indicates that it is not prone to rancidity (Oybunugafor, 2011). Oils with low acidity are considered unfit for consumption (Fuglie, 1999). Moringa seed oil contains all the major fatty acids found in olive oil, and with some modifications it is possible to replace expensive olive oil (Ramachandran et al., 1980).

Moringa is a valuable dietary source of omega-3 polyunsaturated fatty acids (Lolas and Tsaknis, 2002). Several studies have shown that omega- 3 fatty acids help reduce inflammation and pain associated with rheumatoid arthritis (Delaveau, 1980).

Probiotics are live microorganisms that, when consumed, positively impact the balance and function of the human intestinal microflora. This differs from previous definitions that emphasized probiotic interactions with the body's natural gut bacteria (Foller, 1992 and Fuller, 1989). Probiotics are defined as live microorganisms that pass through the gastrointestinal tract and benefit the health of consumers (Tannock, 2000). Probiotics have been reported to have therapeutic properties by modulating immunity, lowering cholesterol, preventing certain cancers, and improving lactose tolerance (Kailasapathy and Chin, 2000).Milk and yoghurt products are successful vehicles to deliver probiotic microorganisms combined with herbal products to consumers (Sun-Waterhouse et al., 2012). To guarantee the effectiveness of a probiotic product, it must contain a minimum of 10-6 – 10-7 colony forming units (cfu) per gram, which is the necessary amount to provide a health benefit to the host (Shah, 2000).

The most popular vehicles for incorporating probiotics into the diet are fermented dairy products such as yogurt (Kailasapathy and Ryoka, 1997) and soft cheeses such as Karish and Tallaga (Osman and Abbas, 1999).

The primary goal of this study was to create probiotic labneh containing Moringa oleifera (leaf powder or seed oil) that is acceptable to consumers. The study also aimed to

analyze the microbiological, chemical, and sensory properties of the product during storage, as well as to enhance its nutritional, therapeutic, and shelf life benefits.

MATERIALS AND METHODS

Labneh preparation:

Labneh made from buffalo's milk standardized to 3% fat. The modified milk heated to 90°C for 15 min. cooled to 40°C then inoculated with 1.5% of the yoghurt starter (Streptococcus thermophiles and Lactobacillus delbrueckii subsp. bulgaricus) and 1.5% Bifidobacterium bifidum (1: 1). Incubation carried out at 40°C until pH 4.8. Cool the fermented milk to 10°C and stir overnight, put it into a sterilized cloth bag, hang it in the refrigerator at 6-7°C for 12 hours, and remove part of the whey The resulting lab was mixed well with 0.5% NaCl. Labneh was divided into fraction C (control labneh) without Moringa oleifera dry leaves, and the other four labneh treatments were fortified with 0.5, 1.0, 1.5 and 2.0% Moringa oleifera dry leaves in T1, T2, T3 and T4, respectively. Moringa oleifera seed oil was used in four treatments: A control labneh without Moringa oleifera seed oil and three treatments fortified with 1%, 2%, and 3% Moringa oleifera seed oil. The resulting labneh products were packaged in plastic containers and stored at 6 ± 1 °C for 21 days and analyzed weekly in triplicate.

Materials:

Fresh Buffalo milk was sourced from the Faculty of Agriculture's herd at Menoufia University in Shibin El-Kom. Moringa oleifera dry leaves and Moringa oleifera seed oil were obtained from the laboratory at the National Research Center, while salt was purchased from the local market.

Bacterial strains:

Active Streptococcus thermophiles EMCC 1043, Lactobacillus delbrueckii subsp. Bulgaricus EMCC 1102, Bifidobacterium bifidum DSM 20082 were obtained from Cairo Mercin, Ain Shams University, Egypt.

Bifidobacterium bifidum were stimulated by three consecutive transfers in a modified MRS broth medium (Ventling and Mistry, 1993), and incubated at 37°C under anaerobic conditions.

Analytical methods:

Total solids, total soluble nitrogen, total protein and ash were determined according to the method described by AOAC (2012). pH was measured using a pH meter (Jenway LTD, Felsted Dunmow, Essex, UK). Titratable acidity and fat content were determined according to Ling (2008), and carbohydrate (%) was determined by calculation. Total volatile fatty acid (TVFA) values were determined according to Kosikowski (1982). Total phenolic compounds were extracted using the method described by Mathaus (2002) and quantified using the Folin Ciocalteu reagent following the procedure outlined by Nassar et al. (2014).

Microbiological examination:

A modified MRs agar was used to enumerate Bifidobacteria (Ventling and Mistry, 1993). Lactobacilli counts enumerated using MRS agar medium. Incubate the plate at 37 °C for 48 h. (De man et al., 1960).

Streptococcus counts were determined using M17 agar according to Terzaghi and Sandine (1975). The plates incubated at 35°C for 48 hr. Calculate the total bacterial number using plate count agar medium (Oxoid). Plates were incubated at 37°C for 48 hours (APHA, 2005).

Coliform bacteria counts were enumerated using the Mackunky agar medium (APHA, 1976). Yeast and mold were counted on potato dextrose agar acidified to pH 3.5 with sterile lactic acid solution (10%). Plates were incubated aerobically at 25°C for 4 days (APHA, 2005). Proteolytic bacterial counts were calculated according to Awad et al. (2005). Enumeration of psychrophilic bacteria was performed using Plate Count Agar medium (Oxoid) and incubated at 5°C for 10 days, following the method described by Cemirkova (2002).

Sensory evaluation:

The sensory characteristics of Labneh treatments were evaluated by ten panelists consisting of staff members and graduate students from the Department of Dairy Science and Technology and Department of Food Science and Technology at the Faculty of Agriculture, Menoufia University. The evaluation was based on a scoring sheet outlined by Salem et al. (2007), with assessments for flavor (60 points), body and texture (30 points), and appearance (10 points).

Statistical analysis:

Data were analyzed using a completely randomized block design and a 2 × 3 factorial design. Newman-Keels' Test used to make the multiple comparisons (Steel and Torrie, 1980) using CoStat Software program, Version 6.4 (2008). Significant differences were determined at $p < 0.05$.

RESULTS AND DISCUSSION

The data in Table (1) summarize the chemical composition of labneh fortified with Moringa oleifera dry leaves. Addition of Moringa oleifera dry leaves had a significant increase in total solids, protein, carbohydrate and ash compared to the control. The highest values were recorded with a treatment intensification of 2% Moringa oleifera dry leaves. This variation can be attributed to the

high total solids, protein, carbohydrate and ash content in Moringa oleifera dry leaves. These results are consistent with El-Sayed et al. (2017) and Salem, et al. (2013).

Table (1). Chemical composition of Labneh fortified with *Moringa oleifera* dry leaves during storage.

Labneh treatments◊	Total solids				Protein				Fat				Carbohydrate				Ash				Soluble nitrogen			
	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21
C	23.49	23.59	23.79	24.00	10.12	10.16	10.22	10.28	9.50	9.50	9.60	9.60	2.95	2.97	2.99	3.01	0.92	0.96	0.98	1.11	0.11	0.18	0.19	0.22
T_1	24.00	24.45	24.69	25.12	10.22	10.44	10.59	10.96	9.50	9.50	9.60	9.70	3.30	3.43	3.39	3.40	0.98	1.08	1.11	1.16	0.15	0.16	0.20	0.24
T_2	24.51	24.83	25.32	25.76	10.43	10.61	11.00	11.21	9.60	9.60	9.60	9.70	3.41	3.53	3.56	3.67	1.07	1.13	1.16	1.18	0.16	0.18	0.21	0.26
T_3	25.30	25.57	25.90	26.30	10.89	10.92	11.09	11.23	9.60	9.60	9.70	9.70	3.68	3.90	3.93	4.16	1.13	1.14	1.18	1.21	0.19	0.22	0.25	0.29
T_4	25.70	25.96	26.40	26.94	11.16	11.19	11.32	11.49	9.70	9.70	9.70	9.80	3.82	3.91	4.15	4.40	1.19	1.20	1.23	1.25	0.21	0.25	0.29	0.33

◊ C: Control Labneh without dry leaves of *Moringa oleifera*. T_1: Labneh with 0.5% dry leaves of *Moringa oleifera*.
T_2: Labneh with 1% dry leaves of *Moringa oleifera*. T_3: Labneh with 1.5% dry leaves of *Moringa oleifera*.
T_4: Labneh with 2% dry leaves of *Moringa oleifera*.

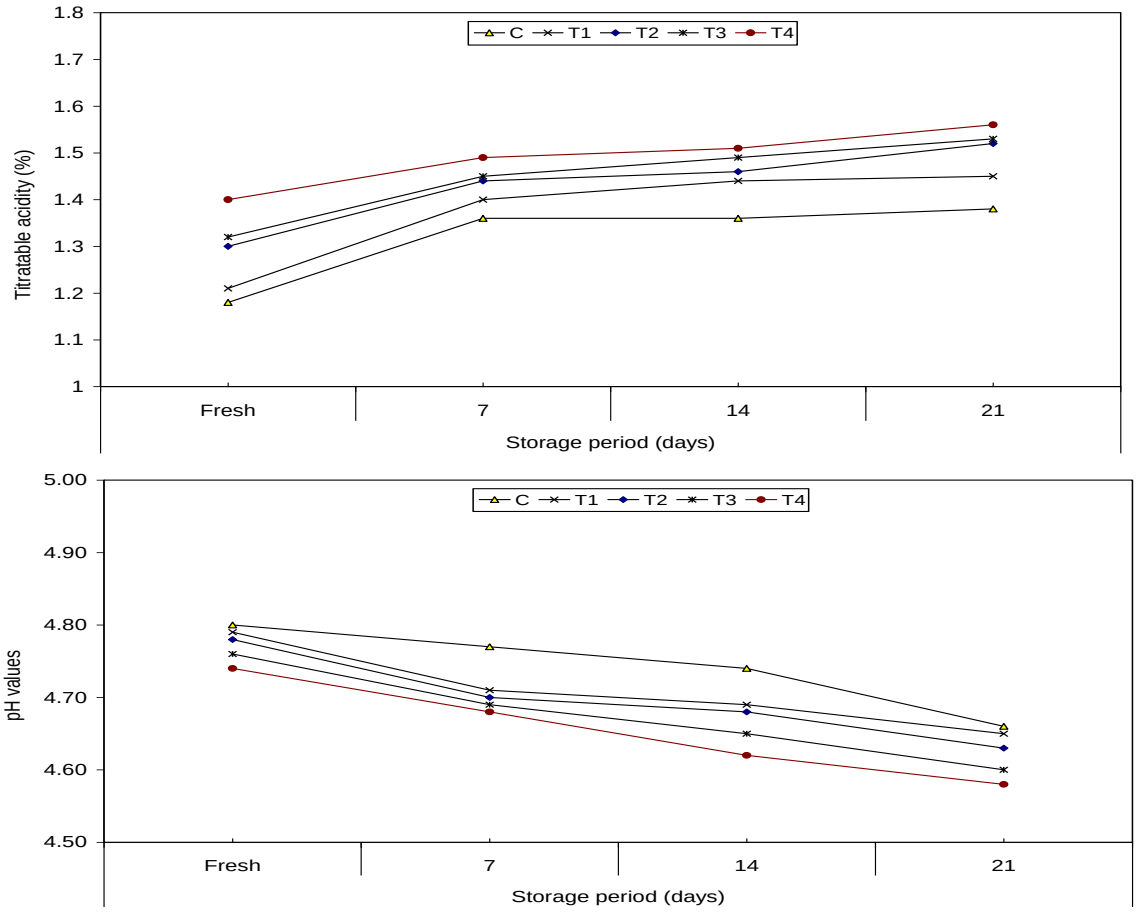

Fig. (1). Effect of adding different concentration of *Moringa oleifera* dry leaves on titratable acidity (%) and pH values of labneh during cold storage.

The contents of soluble nitrogen, total volatile fatty acids, and total phenols (Table 1) showed the same trend. In contrast, the addition of Moringa oleifera dry leaves had no significant effect on the fat content of labneh.

Acidity and pH value data in Fig. (1 and 2) show changes in total acidity and pH values of different labneh treatments during the storage period. One of the most important parameter to determine the quality and shelf-life of dairy products is acidity and pH. The acidity will influence

which microorganisms will survive and grow in a food. Current data indicate that total acidity increased for all treatments during storage.

Generally, fresh labs have an acidity level between 1.18% and 1.40%, increasing to 1.38% to 1.56% during storage. Furthermore, the acidity content increased with Moringa oleifera dry leaves levels and decreased with Moringa oleifera seed oil levels.

These results are consistent with Salem et al. (2013) and Salem, et al. (2014) who reported that addition of Moringa oleifera dry leaves increased the acidity and innovation of labneh to average levels compared to controls fresh and during storage. Changes in pH values of all treatments were in the opposite trend to that acidity.

Chemical composition of functional labneh using different ratio of Moringa oleifera seed oil presented in Table (2). Addition of Moringa oleifera seed oil had a significant effect on total solids and fat. Total solids and fat content increased with the increase of the proportion of Moringa oleifera seed oil . The highest value was recorded with a 3% fortified treatment. In addition, it can be noticed that the protein and ash content of labneh decreased significantly with the increase of Moringa oleifera seed oil addition. This difference can be attributed to the high fat content in these treatments. Similar findings were reported by El-Sayed et al. (2017).Variation in total acidity is a very important factor as it affects shelf life and product acceptability. The results are presented in Figure 1. (2) show that the acidity value of labneh increases during storage, whether treated or controlled (Hassan et al., 2016 and Hassan et al., 2018). Fortified labneh was reported to reach a significantly highest value at the end of the storage period (Abbas and Osman, 1998).

It can be concluded that high total solids increased the growth and activity of starter cultures as reported by (Mahdian and Tehran, 2007). Furthermore, the soluble nitrogen (SN) content in all treatments increased with the progress of the storage period.

The data in Table (3) show the total phenolic and total volatile fatty acid content of laboratories fortified with different levels of Moringa oleifera seed oil when fresh and after 21 days of storage. Labneh enriched with a high concentration of Moringa oleifera seed oil exhibited the highest total phenolic content compared to the control both initially and after 21 days of storage.

The total phenols increased with the addition of Moringa oleifera seed oil, and decreased after 21 days of storage, but were still higher than the control. The Jaffna variety of Moringa oleifera is high in omega-3 fatty acids, particularly oleic acid. Moringa oil contains natural antioxidants, making it superior to other vegetable oils (Bhatnagar and Krishna, 2013). Total volatile fatty acids were significantly increased in all labneh treatments by increasing the level of Moringa oleifera oil. Total volatile fatty acids gradually increased during cold storage until the end of control or treatment storage. These results are consistent with Hassan et al. (2018) and El-Sayed, et al. (2017), who stated that Moringa oil-treated labneh recorded the highest values of TVFA than control. The top values achieved in treatments containing 3% Moringa oleifera seed oil, which is rich in oleic acid, along with its high unsaturation and low peroxide value, suggest that Moringa oil may be suitable for industrial use. (Abd El-Aziz et al., 2007).

Table (2). Chemical composition of Labneh fortified with *Moringa oleifera* seed oil during storage.

Labneh reatments◊	Total solids				Protein				Fat				Carbohydrate				Ash				Soluble nitrogen			
	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21
C	25.11	25.43	25.98	26.01	10.44	10.47	10.82	10.98	9.00	9.00	9.10	9.10	4.55	4.71	4.79	4.89	1.12	1.25	1.27	1.33	0.15	0.35	0.64	0.68
T_1	26.05	26.42	26.54	27.22	10.22	10.24	10.67	10.74	9.80	10.00	10.00	10.10	5.01	5.07	5.11	5.14	1.02	1.11	1.15	1.24	0.14	0.16	0.19	0.22
T_2	26.64	26.95	27.44	27.72	10.01	10.02	10.11	10.13	10.50	10.60	10.80	11.00	5.24	5.34	5.36	5.39	0.89	0.99	1.15	1.20	0.12	0.13	0.15	0.19
T_3	27.76	28.05	28.31	28.58	9.89	9.95	9.99	10.03	11.30	11.50	11.50	12.00	5.83	5.82	5.71	5.66	0.74	0.78	0.81	0.89	0.10	0.12	0.14	0.18

◊ See Table (1)

Table (3): Effect of adding different concentrations of *Moringa oleifera* dry leaves and *Moringa oleifera* seed oil on the total phenolic and total volatile fatty acids of labneh during cold storage.

Labneh treatments◊	Total phenolic (mg gallic acid/100g labneh) in (Moringa dry leaves)		Total volatile fatty acids (mg 0.1 N NaoH/100g labneh) in (Moringa dry leaves)		Total phenolic (mg gallic acid/100g labneh) in (Moringa oil)		Total volatile fatty acids (mg 0.1 N NaOH/100g labneh) in (Moringa oil)	
	Fresh	21	Fresh	21	Fresh	21	Fresh	21
C	3.82	1.99	18.00	26.00	3.63	1.69	12.00	20.00
T_1	14.33	12.01	20.50	30.00	6.15	4.20	19.00	24.00
T_2	16.80	15.22	25.00	32.40	8.52	7.00	28.00	30.00
T_3	30.57	17.57	27.00	35.00	13.22	10.13	30.00	32.00
T_4	37.22	32.66	30.50	38.00	–	–	–	–

◊ See Table (1).

Microbiological examination:

The results in Table (4) show the changes in total counts of labneh products with different treatments during storage at refrigerated temperature (6 ± 1 °C). The results indicate a steady increase in all labneh cheeses over the storage period. The results showed that the total bacterial count was higher in the laboratory fortified with Moringa oleifera dry leaves compared to the control. The results indicated that the addition of Moringa oleifera dry leaves stimulated the bacterial population. This may be due to the high nutritional content of Moringa oleifera dry leaves such as carbohydrates, proteins, minerals and vitamins. Furthermore, the likelihood of bacterial enumeration increased with the addition of Moringa oleifera dry leaves.

On the other hand, the high bacterial counts of such treatments may be due to contamination by added Moringa oleifera dry leaves. These are consistent with those reported by Salem et al. (2013). The viability of Lactobacillus and Streptococcus counts in all labneh treatments increased as the percentage of Moringa increased.

These results may be attributed to Moringa's stimulating effect on these bacteria's growth. These results are in line with Abd El-Fataah et al. (2018) and Zhang et al. (2019), who suggested that Moringa extract promotes the growth of lactic acid bacteria in yoghurt.

Counts peaked at 14 days and then slightly declined, potentially as a result of higher acidity..

It can be seen from Table (4) that the number of bifidobacteria gradually increased throughout the storage period and reached the maximum at 14 days of storage. Moringa oleifera dry leaves appear to stimulate the proliferation of bifidobacteria. These results are in line with Abd El-Salam et al. (2011) who reported that labneh could be considered suitable as a matrix for probiotics due to its high total solids content. Abd El-Fattah et al. (2018) suggested that increasing the concentration of Moringa extract in cream cheese led to a higher cell density of the probiotic. Results in this study revealed that the count of probiotic bacteria remains more than suggested value of more than 107 throughout the storage period (21 days), Shah (2000) proposed that Moringa-fortified probiotic labneh could be utilized as a suitable carrier for probiotic bacteria. Overall, probiotic bacteria, especially bifidobacteria, were unable to survive the acidic conditions (Dave and Shah, 1997).

The results in Table (4) show the changes in proteolytic bacteria counts. The results show that there are a gradual increase was observed throughout the storage period of all labneh cheeses. Mold and yeast counts in labneh are indicators of quality and shelf life. In this regard, no molds and yeasts were detected in all treatments fresh in the laboratory and throughout the storage period. This may be due to the antifungal and antibacterial activity of Moringa leaves. Moringa has been reported to contain phenolic and flavonoid compounds that are primarily responsible for its antimicrobial properties. These results are in line with those noted by Rajanandh and Kavitha (2010), Salem et al. (2013) and Mohamed et al. (2018). However, mold and yeast were detected in the control after a storage period of 14 days. Coliform and psychrophilic bacteria were not found in all labneh treatments, either fresh or during storage, suggesting that appropriate measures were taken during processing to avoid contamination during processing and that the product was of good quality. These results are consistent with the findings of Salem et al. (2013) and Abd El-Fataah et al. (2018).

Table (5) shows the labneh manufactured with different percentages of Moringa oleifera seed oil and the total bacterial count during refrigeration (6 + 1°C). The results

showed that the total count increased gradually as the oil percentage increased, suggesting that Moringa oleifera seed oil has a stimulating effect on the starter culture. This could be attributed to the high nutritional value of Moringa oleifera seed oil, which includes essential fatty acids, vitamins, and antioxidants. Moreover, the higher concentration of Moringa oil led to a rise in bacterial counts as reported by El-Sayed et al. (2017), which may be due to the probiotic bacteria present in the labneh samples.

The high total solids content has also been found to enhance the growth and activity of the starter culture as reported by Mahdian and Tehrani (2007). Count increased gradually with storage period advanced in all labneh treatments and reached their maximum after 14 days of storage period then decreased, which might be due to the development of acidity and the antimicrobial properties of Moringa oleifera seed oil (Hassan et al., 2018).

Table (4): Effect of labneh manufactured from different treatments with *Moringa oleifera* dry leaves on Microbial examination. (log_{10} cfu/g)*.

Labneh treatments◊	Total bacterial				Lactobacilli				Streptococci				Bifidobacteria				Proteolytic b.				Mould&Yeast			
	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21
C	8.97	9.07	9.20	9.27	7.93	8.09	8.17	8.11	8.16	8.19	8.20	7.79	9.51	9.62	9.68	9.60	2.47	2.69	2.90	2.95	ND	ND	3.39	3.49
T_1	9.00	9.13	9.25	9.34	7.97	8.18	8.27	8.14	8.17	8.24	8.26	8.12	9.54	9.64	9.69	9.65	2.60	2.77	2.90	3.00	ND	ND	ND	ND
T_2	9.17	9.22	9.30	9.38	8.00	8.20	8.27	8.20	8.19	8.29	8.30	8.17	9.59	9.67	9.73	9.69	2.77	2.84	2.95	3.11	ND	ND	ND	ND
T_3	9.19	9.29	9.32	9.42	8.06	8.20	8.28	8.27	8.25	8.30	8.34	8.22	9.68	9.77	9.77	9.74	2.84	2.95	3.00	3.17	ND	ND	ND	ND
T_4	9.23	9.30	9.39	9.45	8.15	8.26	8.29	8.27	8.39	8.42	8.44	8.38	9.69	9.79	9.87	9.76	2.95	3.04	3.14	3.27	ND	ND	ND	ND

◊ See Table (1).
*cfu: colony forming unit.

Table (5): Effect of labneh manufactured from different treatments with *Moringa oleifera* seed oil on Microbial examination. (log_{10} cfu/g)*.

Labneh treatments◊	Total bacterial				Lactobacilli				Streptococci				Bifidobacteria				Proteolytic b.				Mould&Yeast			
	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21
C	7.79	7.83	7.88	7.79	7.72	7.99	7.90	7.79	7.65	7.81	8.07	8.25	9.43	9.47	9.50	9.41	3.00	3.07	3.17	3.23	ND	ND	2.95	3.11
T_1	7.98	8.00	8.02	7.94	7.80	8.03	7.94	7.87	7.74	7.90	8.16	8.34	9.46	9.49	9.53	9.44	2.95	3.00	3.07	3.17	ND	ND	ND	ND
T_2	7.99	8.14	8.15	8.11	7.97	8.17	8.04	7.99	7.83	7.99	8.17	8.39	9.47	9.50	9.55	9.50	2.90	2.90	3.00	3.07	ND	ND	ND	ND
T_3	8.06	8.17	8.27	8.13	8.17	8.23	8.21	8.19	7.85	8.00	8.30	8.53	9.57	9.58	9.59	9.53	2.60	2.60	2.81	3.00	ND	ND	ND	ND

◊ See Table (1).
*****cfu: colony forming unit.

The number of lactobacilli increased by increasing the oil percentage total solids, which proves that Moringa oleifera seed oil promotes the growth of organisms, mainly lactic acid bacteria such as Lactobacillus. These results are in agreement with Kumalalningish et al. (2011), and reached the maximum count after 7 days of storage. It then declines until the end of storage, which may be attributed to the development of acidity and antibacterial properties of Moringa oil.

Streptococci counts increased as the oil level was increased throughout the storage period, with the highest counts observed in the treatment containing 3% Moringa oleifera seed oil. This suggests that lactic acid bacteria were able to thrive due to the presence of essential fatty acids in Moringa oleifera seed oil. These results are similar to those found by Mohamed et al. (2013) and El-Sayed et al. (2017).

Bifidobacteria counts (Table 5) increased by the increase of the Moringa oleifera seed oil ratio and reached their maximum count at 14 day then slightly decreased during the storage period, but still higher than those health benefits claims. proteolytic bacteria decreased by increasing of Moringa oleifera seed oil concentration.

On the other hand, the number of proteolytic bacteria increased with storage time, and these results indicated that proteolytic bacteria were able to grow in the presence of Moringa oleifera seed oil. These results are in line with Salem (2007).

Mold and yeast counts were not detected in all labneh

treatments in fresh labneh throughout the storage period and only appeared after 14 days of storage in control labneh. These results are consistent with El-Sayed et al. (2017); they observed no yeast and mold in labneh fortified with Moringa oil, either fresh or during refrigeration, due to the antibacterial activity of moringa oil. Other researchers report that Moringa contains high percentages of phenolic compounds, flavonoids, and carotenoids (Rajanandh and Kavtha, 2010). Therefore, Moringa oleifera seed oil can be considered a good dietary source.

It could be observed that neither psychrophiles nor coliforms were detected in all laboratory treatments, either when fresh or during storage, which attests to good hygienic conditions in laboratory production.

Sensory evaluation:

Sensory evaluation is very important to determine the quality and shelf life of dairy products. The sensory properties results in Table (6) showed that the addition of Moringa oleifera seed oil had a favorable effect on flavor, mouthfeel and texture as well as the overall score.

Adding Moringa oleifera seed oil to labneh enhanced flavor without compromising quality. The sensory property values increased with the concentration of Moringa oleifera seed oil. The sensory properties of all labneh treatments decreased during storage. Control samples were molded after 14 days of storage. The treatment with 3% Moringa oleifera seed oil was preferred by the panelists.

Additionally, labneh samples with added Moringa oleifera seed oil exhibited satisfactory taste, texture, and appearance. This could be attributed to the pleasant aroma of Moringa oleifera seed oil, enhancing the nutritional value, therapeutic properties, and shelf life of the labneh (Belew et al., 2012).

Table (6). Effect of addition of *Moringa oleifera* dry leaves and *Moringa oleifera* seed oil on the organoleptic properties of Labneh during cold storage.

Labneh treatments◊	Moringa dry leaves																Moringa oil															
	Flavor (60)				Body and texture (30)				Appearance (10)				Total score (100)				Flavor (60)				Body and texture (30)				Appearance (10)				Total score (100)			
	Storage period (days)																															
	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21	0	7	14	21
C	59	58	-	-	29	28	-	-	9	9	-	-	97	95	-	-	55	54	-	-	26	26	-	-	9	8	-	-	90	88	-	-
T_1	58	58	57	55	29	28	27	26	9	9	8	8	96	95	92	89	56	56	55	54	27	27	26	25	9	9	8	8	92	92	89	87
T_2	58	57	54	54	28	28	27	26	9	9	8	7	95	94	89	87	58	57	56	55	28	27	27	26	9	8	7	7	95	92	90	88
T_3	54	53	50	50	28	27	26	25	8	8	7	7	90	88	83	82	59	58	57	55	28	27	27	26	9	9	8	8	96	94	92	89
T_4	53	53	51	50	28	27	26	25	8	7	7	7	89	87	84	82	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

◊ See Table (1).

Table (7). Statistical analysis of physiochemical composition and sensory evaluation of Labneh fortified with *Moringa oleifera* dry leaves during stored at 6 ± 1°C for 21 days.

Labneh properties	Effect of treatments						Effect of storage period (days)				
	Multiple comparison•						Multiple comparison•				
	Mean Squares	C◊	T_1	T_2	T_3	T_4	Mean Squares	0	7	14	21
Total solids (%)	7.453*	C	B	B	A	A	0.657	A	A	A	A
Titratable acidity (%)	0.038*	C	B	AB	AB	A	0.115*	B	A	A	A
Ash (%)	0.186*	C	B	B	A	A	0.088*	D	C	B	A
Fat (%)	1.776	A	A	A	A	A	0.406	A	A	A	A
Protein (%)	5.723*	B	B	B	B	A	0.805	A	A	A	A

Carbohydrate (%)	1.778*	C	B	B	B	A	0.616*	D	C	B	A
Soluble nitrogen (%)	0.017*	B	B	B	A	A	0.030*	D	C	B	A
pH value	0.017*	A	AB	AB	B	C	0.018*	A	A	A	B
Total phenols	876.309*	E	D	C	B	A	162.262*	A			B
Total volatile fatty acids	62.719*	C	BC	B	A	A	230.741*	B			A
Sensory properties Flavor	83.850*	A	A	B	C	C	48.400*	A	A	B	C
Body and texture	2.625	A	A	A	A	A	25.200*	A	AB	BC	C
Appearance	4.500*	AB	A	AB	B	B	10.800*	A	A	B	B
Total scores	164.100*	B	A	C	D	D	229.200*	A	B	C	D

◊ See Table (1).

● For each effect the different letters in the same row means the multiple comparisons are different from each other, letter A is the highest mean followed by B, C, …. etc.

* Significant at 0.05 level ($p \leq 0.05$).

Conclusion:

The use of Moringa oleifera seed oil as a preservative in labneh resulted in the suppression of microorganism growth, including yeasts, molds, and proteolytic bacteria. Incorporating Moringa oleifera dried leaves and Moringa oleifera seed oil at concentrations of 0.5% and 3.0%, respectively, improved the texture, flavor, and appearance of limes while extending their shelf life.

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