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# Research Article
# Improving the Nutritional Value and Extending Shelf Life of Labneh by Adding *Moringa oleifera* Oil

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## Abstract

**Objective:** This study aimed to prepare labneh from skim buffalo's UF-retentate fortified with *Moringa oleifera* oil using different ratios (100, 150 and 200 mg $mL^{-1}$) to increase the nutritional and quality of final product. **Methodology:** The antimicrobial activity of the *Moringa oleifera* oil was assayed against Gram-positive strains (*Bacillus cereus*, *Staphylococcus aureus* and *Bacillus subtilus*) Gram-negative strains (*Escherichia coli*, *Yersinia enterocolitica*, *Salmonella typhmirum*, *Listeria monoytogenes* and *Pseudomonas aeruginosa*), Yeast (*Saccharomyces cerevisiae*) and other three fungal strains. Also, labneh was fortified with different concentration of *Moringa oleifera* oil. Functional labneh mixture was inoculated with *Lactobacillus acidophilus* (1%), *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (2%). The chemical composition, antioxidant capacity, vitamins, microbiological analysis and rheological properties of the *Moringa oleifera* oil and labneh were determined. **Results:** The *Moringa oleifera* oil displayed good effect against all of the established microorganisms which the diameter of inhibition zone ranged from 3-14 mm for different concentration of *Moringa oleifera* oil. Moreover, the acidity and peroxide value for *Moringa oleifera* oil were 0.91% and 19.5 meq $kg^{-1}$, respectively. The DPPH scavenging activity (mmol TE $kg^{-1}$) of oil was 101.2 mM $kg^{-1}$. Also, the fatty acid composition revealed that oleic acid is the major fatty acid of the oil 81.75%. *Moringa oleifera* oil content 0.129, 0.461, 0.595 mg/100 g of the $\delta$, $\gamma$, $\alpha$ tocopherols, respectively. The total solid, fat, total volatile fatty acid, DPPH scavenging activity, tocopherols and total lactic acid bacterial counts content of labneh increased with the rise of the percentage of added *Moringa oleifera* oil. Contrary, the protein, ash, acidity and water soluble vitamins (B1, B2, B3, B6 and B9) content of labneh decreased with the increase of the percentage of added *Moringa oleifera* oil. Rheological properties of labneh decreased with the increase of the percentage added of *Moringa oleifera* oil and storage period. The count of molds and yeasts in control samples appeared after 2 weeks of storage and raise till the end of storage period. Sensory properties of labneh samples improved and gained higher scores with increase of the ratios of *Moringa oleifera* oil compared with other samples. **Conclusion:** Fortified labneh with *Moringa oleifera* oil can be considered as new product with functional properties and extended the shelf life of this product.

Key words: *Moringa oleifera* oil, labneh, vitamins, antioxidant capacity, antimicrobial activity, shelf life

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

## INTRODUCTION

Labneh is a popular fermented milk product it gained from yoghurt after deletion a part of its water, lactose and salts, it has a creamy or milky color, a soft and good spread ability, a clean flavor and slight acidity[1]. *Moringa oleifera* oil is the main part multifunctional plants in the world, with a great amount of economic, nutritional and health benefits. It is usually used for beauty care and as fuel for food preparation and for light in developing countries[2].

*Moringa oleifera* seeds are rich in proteins and oil. It gave high oil yield and it used for a variety of purposes[3,4]. Also, it is admirable quality and slow turn into rancid, which has good antioxidant capacity that flavonoids get antioxidant action during chelating process and this play a defensive role in cancer and heart disease[5]. Utilization of this oil able to give health benefits in terms of hypocholesterolemic effects and scavenge of free radicals in the body[6]. Thus, the importance of the antioxidant components of *Moringa* oil in the protection of health is moving to employ foods like medicine in the management of different chronic diseases. In addition, *Moringa oleifera* and its extracts have antimicrobial activity against wide range of pathogenic micro-organisms such as, *Escherichia coli*, *Enterobacter* spp., *Pseudomonas aeroginosa*, *Salmonella* spp., *Staphylococcus aureus*, *Streptococcus* and *Candida albicans*[7], so it can be utilize as an alternative to antibiotic in the treatment of infectious diseases. Moreover, *Moringa oleifera* oil preparations can be used as a water disinfectants because of its low coast and capable of attract and stick faster to bacteria and viruses that are found in contaminated and turbid water[8].

Different extraction methods are engaged to get oil from *Moringa oleifera* seeds and many researchers found that the major component found in this oil is unsaturated fatty acid (oleic acid), which was suggested for use in pharmaceutical research[9]. *Moringa oleifera* is rich dietary source of Omega 3 poly unsaturated fatty acids[10]. Several studies showed that Omega 3 fatty acid aid to decline inflammation and pain related to rheumatoid arthritis[11].

Lactic bacteria was considered main group in bacteria that used for fermented food and they are found on various substrates especially probiotic strains[12]. The probiotic *Lactobacillus acidophilus* considered important bacteria used in the fermentation of foods especially dairy products and able to break down carbohydrates to produce alcohol, carbon dioxide and lactic acid[13]. The metabolic activity of this microorganism contributed in production of flavor and aroma that enhancement the organoleptic properties of many fermented foods[14,15]. So that, the combination between *L. acidohilus* and *Moringa oleifera* oil may be provide healthy probiotic food supplement.

Therefore, the objectives of this study were to determine antimicrobial, physicochemical, antioxidant contents and unsaponifiable of oil extracted from the seeds of Egyptian *Moringa oleifera* trees. Also, manufacture of healthy and functional labneh fortified with *Moringa oleifera* oil to enhance the antioxidant, microbiological and rheological properties of labneh to improve the shelf life of this product.

## MATERIALS AND METHODS

**Materials:** Fresh buffalo's skim UF-retentate was procured from Animal Production Research Institute, Agriculture Research Center, Dokki, Egypt. Cold pressed *Moringa oleifera* oil was purchased from the Moringa plantation unit of the National Research Center. Trichloroacetic acid (TCA) was obtained from Sigma-Aldrich (Seeize, Germany), methanol (HPLC grade) from (Fisher Scientific Limited, UK). Potassium hydroxide, sodium sulphate anhydrous and calcium chloride (Analytical reagents) and ammonia solution (25%) were obtained from El Nasr Pharmaceutical Chemicals Co. (Cairo, Egypt), phenolphthalein and pyrogallol from (Alpha chemika, Bumbai, India), diethyl ether (extra pure) and absolute ethanol from (molekula, Dorset, UK), n-hexane, methylene chloride, methanol and acetonitrile (HPLC grade) from (Fisher Scientific Limited, UK). Double-distilled water was prepared using a Milli-Q water system (Millipore, MA, USA). Standards of thiamin (vitamin B1), riboflavin (vitamin B2), pyridoxine (vitamin B6), niacin (vitamin B3), folic acid (vitamin B9) $\alpha$-$\gamma$ and $\delta$ tocopherol (vitamin E) were purchased from Sigma Chemical Co., St Louis, MO, USA.

**Pathogenic strains:** *Bacillus cereus* B-3711, *Bacillus subtilus*, *Asparagillus flavus* 3357 and *Saccharomyces cerevisiae* Y-2223 were provided by the Northern Regional Research Laboratory Illinois, USA (NRRL). *Listeria monocytogenes* 598 was provided by the Department of Food Science, University of Massashusetts, Ambert MA, USA. *Escherichia coli* 0157:H7 and *Staphylococcus aureus* were isolated and serologically identified by dairy microbiological Lab., National Research Center. *Yersinia enterocolitica* were obtained from Hungarian National Collection of Medical Bacteria, OKI, Gyaliut 2-6, H-1966 Budapest, Hungary. *Asparagillus niger*, *Pseudomonas aeruginosa* and *Pencillium requfortii* J5 were obtained from Department of Microbiology, Swedish University of Agricultural Sciences.

The bacterial pathogenic strains were activated in trypton soya broth, incubated at 37°C for 24 h. Yeast

and mold strains were activated in malt extract broth, incubated at 25°C for 72 h.

**Lactic acid strains:** *Lactobacillus delbrueckii* sub sp., *bulgaricus* Lb-12 DRI-VAC, provided by Northern Regional Research Laboratory. Illinois, USA. *Streptococcus thermophilus* CH-1 obtained from Chr. Hansens's Lab., Denmark, *Lactobacillus acidophilus* CH-2 was obtained from Chr. Hansen's Lab., Denmark.

## Method

### Antibacterial activity of *Moringa oleifera* oil

**Preparation of different concentration from oil extract:** About 1.0 mL of oil extract was dissolved in 5.0 mL DMSO (dimethyl sulfiooxide) to get 200 mg $mL^{-1}$ solution, after that different dilution were prepared in DMSO to get 150, 100, 75 and 50 mg $mL^{-1}$ solution. The antibacterial assay of different concentration of *Moringa oleifera* oil extract performed by agar well diffusion method using nutrient agar medium according to Dodiya and Amin[16]. The nutrient agar was poured into the petri dishes and allowed to solified, the pathogenic strains 0.1 mL (approximately $10^9$ cells $mL^{-1}$) of the tested microorganisms was spread on the surface of the agar found in petri dish using a sterile swab. The plates were rested to 2 h at 37°C to allow the agar saturated with pathogenic strains. For the agar well diffusion method, a well was prepared in the plates with a cup borer (0.5 cm) and 50 µL of the each oil concentration was inoculated directly into the well. The plates were incubated at 37°C for 24 h. After the incubation period the inhibition zones around the each well was measured in millimeters.

**Gas-liquid chromatographic analysis of fatty acids methyl esters:** The fatty acid composition of the *Moringa oleifera* oil sample used in this study was identified and measured using gas liquid chromatography on a Hewlett Packard Model 6890 with a flame ionization detector using capillary column 30.0 m×530 µm×1.0 µm. The carrier gas used was nitrogen set at a flow rate of 15 mL $min^{-1}$ and split-ratio of 8:1. Esterification of fatty acid for methyl ester preparation was carried out according to Luddy *et al.*[17].

**Determination of peroxide value and acidity for *Moringa oleifera* oil:** Peroxide value and acidity for *Moringa oleifera* oil were determined according to AOAC[18] and IUPAC[19].

**Preparation of functional labneh:** Labneh was made using the method described by Shamsia and El-Ghannam[20]. Buffalo's UF-retentate were heated to 72°C for 3-5 min and then cooled to 42°C. The labneh was divided into 5 batches. The first (containing only the yoghurt starter cultures 2%) and the second (containing only yoghurt starter cultures 2% and *L. acidophilus* 1%) were served as a control (C1 and C2) and the others three batches mixed individually with *Moringa oleifera* oil in ratios of 100, 150 and 200 mg $mL^{-1}$ UF-retentate for T1, T2 and T3, respectively using the electric blender (Molinex blender). Treatments T1, T2 and T3 were inoculated with *Lactobacillus acidophilus* (1%), *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (2%) and all treatments packaged in plastic yoghurt cups (70 mL). The cups were incubated at 42°C till coagulation. The treatments were stored at refrigerator (5±2°C) till the end of storage period. Samples of labneh were analyzed for texture profile changes. Chemical, microbiological, rheological and sensory attributes were determined when fresh and during storage. The experiment was carried out in triplicate. Data was reported as the average of three independent.

**Chemical analysis:** Fresh labneh samples were chemically analyzed for total solids (T.S), fat/dry matter (F/DM), acidity and ash content according to AOAC[21]. The pH values were measured using a digital laboratory Jenway 3510 pH meter, UK. Bibby Scientific LTD. Stone, Stafford shire, ST 15 OSA. Total Nitrogen (TN) and Soluble Nitrogen (SN) contents were determined using the semi micro-Kjeldal method as mentioned by Ling[22]. Total Volatile Fatty Acids (TVFA) value was determined according to the method described by Kosikowski[23] values were expressed as mL of 0.1 M NaOH/100 g labneh. Antioxidants (DPPH) were detected according to Zheng and Wang[24].

**Microbiological analysis:** Labneh samples were microbiologically analyzed for *Lactobacillus bulgaricus* counts using MRS agar according to De Man *et al.*[25]. The plates were incubated at 37°C for 48 h under anaerobic condition. *Streptococcus thermophilus* counts were determined using M17 agar according to Terzaghi and Sandine[26]. The plates were incubated at 35°C for 48 h under aerobic conditions. *Lactobacillus acidophilus* counts were determined on *Lactobacillus* selective MRS agar plus 0.2% oxgall[27]. The plates were incubated at 37°C for 48 h under anaerobic conditions. Coliform bacterial counts were enumerated using violet red bile agar medium[28]. The plates were incubated at 37°C for 18 h. Total bacterial counts were enumerated using plate count agar medium (Oxoid). The plates were incubated at 37°C for 48 h[29]. Yeasts and Molds counts were enumerated using potato dextrose agar acidified to pH 3.5 with sterile lactic acid solution (10%)[30]. The plates were aerobically incubated at 25°C for 4 days.

**Texture profile analysis of functional labneh:** Texture profile samples measurements were carried out according to Bourne[31] with universal testing machine (Cometech, B type, Taiwan) provided with software. Back extrusion cell with 35 mm diameter compression disc was used. Two cycles were applied, at a constant crosshead velocity of 1 mm sec G1, to 25% of sample depth and then returned. From the resulting force-time curve, the values for texture attributes, i.e., firmness (N), gumminess (N), chewiness (N), adhesiveness (N.S), cohesiveness, springiness and resilience were calculated from the TPA graphic.

### Determination of vitamins

**Preparation of vitamin standards:** A stock standard solution (100 μg $mL^{-1}$) of thiamin B1, riboflavin B2, niasin B3, pyridoxine B6 and folic B9 were prepared with water and a stock standard solution (100 μg $mL^{-1}$) of vitamin (E) α-γ and δ tocopherol were prepared with acetonitrile. All standards stored at 4°C before use.

**Determination of fat-soluble vitamin concentration (vitamin E by HPLC):** Vitamin E (α-γ and δ tocopherol) was determined by HPLC analysis after an extraction procedure previously described by Escriva *et al.*[32]. The HPLC analysis was performed with an Agilent 1260 HPLC system (Agilent Technologies, USA), equipped with a quaternary pump, auto sampler injector with 20 μL fixed loop injector, thermostat compartment for the column and photodiode array detector. The chromatographic column was ODS H optimal (150×4.6 mm, 5 μm film thicknesses). The column was kept at room temperature. Aliquot (20 μL) of the standard or a sample was injected and then eluted with the mobile phase of acetonitrile/methylene chloride/methanol (70:20:10 v/v/v) at an isocratic flow rate of 1 mL $min^{-1}$ with a total runtime of 15 min. Detection wavelength for detection of α-tocopherol was set at 290 nm. Vitamin E (α-γ and δ tocopherol) content was further expressed in μg/100 g of fresh weight.

### Determination of water-soluble vitamin

**Vitamin thiamin (B1), riboflavin (B2), niacin (B3), pyridoxine (B6) and folic (B9):** Vitamins B1, B2, B3, B6, B9 were determined by HPLC analysis after an extraction procedure was carried out according to Albala-Hurtado *et al.*[33]. The HPLC analysis was performed with an Agilent 1260 HPLC system (Agilent technologies, USA), equipped with a quaternary pump, auto sampler injector with 20 μL fixed loop injector, thermostate compartment for the column and photodiode array detector. The chromatographic column was C18 Zorbax XDB (250×4.6 mm, 5 μm film thicknesses). The column was kept at room temperature at a flow rate of 0.8 mL $min^{-1}$ with a total runtime of 12 min. Separation of vitamins was carried out by gradient elution with (a) Methanol and (b) 1% TFA containing water. The elute composition was initially 8% A+92% B, held for 2 min and changed linearly to 92% A+8% B in the next 4 min and held for 6 min. Detection wave length for detection of B1, B2, B3, B6, B9 and pyridoxine were set at 280 nm.

**Sensory evaluation properties:** Fresh and stored labneh samples were evaluated for their organoleptic properties. Appearance (10 points), body and texture (10 points) and flavor (10 points) were evaluated, when fresh and during storage till 30 days at refrigerator (5±2°C) by members of National Research Center (NRC) according to score card described by Tarakci *et al.*[34].

**Statistical analysis:** The data were analyzed according to Statistical Analysis System Users Guide SAS Institute[35] (SAS Institute, Inc, U.S.A). Separation among means in triplicates was carried out using Duncan multiple tests. All result data analysis in two ways accepts the chemical composition data analysis in one way.

## RESULTS AND DISCUSSION

**Antimicrobial activity of *Moringa oleifera* oil using agar well diffusion method:** Table 1 shows diameter of inhibition zones of pathogenic strains growth at varying concentrations of *Moringa oleifera* oil. *Moringa oleifera* oil showed stronger antibacterial activity against studied Gram-positive bacteria and Gram-negative bacteria more than mold and yeast. The diameter zone of inhibition recorded 14.00-10.00 for Gram-positive bacteria and recorded 14.00-7.00 for Gram-negative bacteria, moreover the diameter of zone recorded 7.00-5.00 for mold and yeast using 200 mg oil $mL^{-1}$ and the zone of inhibition decreased with the lowest concentration of *Moringa oleifera* oil. Also, *Moringa oleifera* oil showed significantly ($p<0.05$) higher inhibition on *B. cereus* at 200 mg oil $mL^{-1}$ concentration and the least inhibition was observed at the same concentration on *P. requfortii*. However, there were slight significant differences ($p>0.05$) between concentrations 50 and 75 mg oil $mL^{-1}$ on their effect and the same 2 concentration had lowest antimicrobial effect compared with the highest concentration on pathogenic strains. Rahman *et al.*[36]

Table 1: Antimicrobial effect of *Moringa oleifera* oil on different pathogenic strains

| | Diameter of inhibition zone (mm) | | | | |
|---|---|---|---|---|---|
| Pathogenic strains | 50 mg mL$^{-1}$ | 75 mg mL$^{-1}$ | 100 mg mL$^{-1}$ | 150 mg mL$^{-1}$ | 200 mg mL$^{-1}$ |
| *Bacillus cereus* | $6^{Da}$ | $9^{Ca}$ | $11^{Ba}$ | $12^{Ba}$ | $14^{Aa}$ |
| *Bacillus subtilus* | $5^{Cb}$ | $7^{Bb}$ | $8^{Bb}$ | $11^{Ab}$ | $12^{Ab}$ |
| *Staphylococcus aureus* | $4^{Db}$ | $6^{Cb}$ | $7^{Bb}$ | $8^{Bc}$ | $10^{Ac}$ |
| *Pseudomonas aeruginosa* | $4^{Cb}$ | $6^{Bb}$ | $7^{Bb}$ | $10^{Ab}$ | $11^{Ac}$ |
| *Listeria monoytogenes* | $7^{Da}$ | $9^{Ca}$ | $11^{Ba}$ | $13^{Aa}$ | $14^{Aa}$ |
| *Escherichia coli* | $4^{Db}$ | $7^{Cb}$ | $8^{Bb}$ | $9^{Bc}$ | $11^{Ac}$ |
| *Yersinia enterocolitica* | $3^{Dd}$ | $4^{Cc}$ | $5^{Cc}$ | $7^{Bd}$ | $9^{Ad}$ |
| *Salmonella typhmirum* | - | $2^{Cd}$ | $3^{Cd}$ | $5^{Be}$ | $7^{Ae}$ |
| *Aspargillus niger* | - | $3^{Cc}$ | $5^{Bc}$ | $6^{Ad}$ | $7^{Ae}$ |
| *Asparagillus flavus* | - | - | $2^{Bd}$ | $3^{Bf}$ | $5^{Af}$ |
| *Pencillium requfortii* | - | - | - | $3^{Af}$ | $4^{Af}$ |
| *Saccharomyces cerevisiae* | - | - | $2^{Bd}$ | $4^{Ae}$ | $5^{Af}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$)

Table 2: Fatty acids composition of *Moringa oleifera* oil by GLC analysis

| Fatty acids | Fatty acids (%) |
|---|---|
| Palmito oleic acid | 1.81 |
| Palmitic acid | 7.07 |
| Oleic acid | 81.75 |
| Stearic acid | 6.62 |
| Arachiddic acid | 2.76 |

suggests that extracts of *Moringa oleifera* seeds contain antibacterial potentials bio-compounds are more than extract of leaves. According to Jahn *et al.*[37] the major bactericidal substances in moringa seeds recognized as pterygospermin, moringine, glycosides 4-(α-L-rhamnosyloxy)-benzylisothiocyanate and 4-(α-L-rhamnosyloxy)-phenylacetonitrile. These substances possess antimicrobial effect largely against *B. subtilis*, *E. coli*, *P. aeruginosa* and *Shigella*. Aney *et al.*[38] reported that *Moringa oleifera* seeds have an antibiotic called pterygospermin which is able to destroy microorganisms in water.

**Fatty acids profile of *Moringa oleifera* oil:** Fatty acids fractionations of *Moringa oleifera* oil were demonstrated in Table 2. Obtained data observed that five fatty acids have been identified. Obviously, the oleic, palmitic, stearic, palmito oleic fatty acid contents of *Moringa oleifera* oil were 81.75, 7.07, 6.62, 2.76 and 1.81% ,respectively. Indeed, the oleic acid was recorded the highest unsaturated fatty acid in *Moringa oleifera* oil. These results are agreement with the previous studies[39,6]. The cold pressed *Moringa oleifera* oil contain about 0.91% acidity and 19.5 meq kg$^{-1}$ of peroxide value.

**Chemical composition of functional labneh using different ratios of *Moringa oleifera* oil:** Chemical composition of functional labneh using different ratios of *Moringa oleifera* oil is presented in Table 3. Addition of *Moringa oleifera* oil had significant effect on T.S, fat and F/DM. The T.S and fat content increased by increasing the added ratio of *Moringa oleifera* oil. The highest values were recorded with treatments fortified with 15 and 20%. Also, it could be noticed that protein content of labneh was significantly decreased by approximately 20, 32 and 36% in labneh supplemented with 10, 15 and 20% *Moringa oleifera* oil, respectively, compared with control treatments. Also, ash content decreased with increasing addition level of *Moringa oleifera* oil. This difference could be attributed to the high fat content in these treatments.

Table 3: Chemical composition of functional labneh using different ratios of *Moringa oleifera* oil

| Treatments | T.S (%) | Moisture (%) | Fat (%) | F/DM (%) | Protein (%) | Ash (%) |
|---|---|---|---|---|---|---|
| C1 | $25.62^{D}$ | $74.38^{B}$ | $2^{D}$ | $7.80^{E}$ | $21.39^{A}$ | $2.14^{A}$ |
| C2 | $24.66^{E}$ | $75.34^{A}$ | $2^{D}$ | $8.11^{D}$ | $21.38^{A}$ | $2.12^{B}$ |
| 1 | $31.83^{C}$ | $68.17^{C}$ | $12.5^{C}$ | $39.27^{C}$ | $17.05^{B}$ | $1.76^{C}$ |
| 2 | $35.71^{B}$ | $64.30^{D}$ | $17.4^{B}$ | $48.73^{B}$ | $14.61^{D}$ | $1.68^{D}$ |
| 3 | $39.30^{A}$ | $60.70^{E}$ | $22.5^{A}$ | $57.25^{A}$ | $13.53^{C}$ | $1.41^{E}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil, C2: Labneh cheese without *Moringa oleifera* oil, T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

**Influence of adding different *Moringa oleifera* oil concentration on chemical composition of labneh:** The changes in total acidity are very imperative factor, because it influence on the shelf life and the acceptability of product. The results offered in Table 4 showed that acidity values of labneh increased during storage. The significantly highest values were achieved with fortified labneh at the end of storage period as reported with Abbas and Osman[40]. It could be concluded that

Table 4: Influence of adding different *Moringa oleifera* oil concentration on chemical composition of labneh storage at 5±2°C for 30 days

| | | Control | | Added *Moringa oleifera* oil (%) | | |
|---|---|---|---|---|---|---|
| Components | Storage (days) | C1 | C2 | 10 | 15 | 20 |
| Acidity | 0 | $1.06^{Ce}$ | $1.08^{Bd}$ | $1.17^{Ae}$ | $0.99^{De}$ | $0.92^{Ed}$ |
| | 7 | $1.44^{Bd}$ | $1.47^{Ac}$ | $1.26^{Ed}$ | $1.31^{Dd}$ | $1.35^{Cc}$ |
| | 15 | $1.85^{Bc}$ | $1.93^{Ab}$ | $1.67^{Ec}$ | $1.74^{Dc}$ | $1.80^{Cb}$ |
| | 21 | $2.19^{Ab}$ | $2.00^{Ba}$ | $1.69^{Db}$ | $1.80^{Cb}$ | $1.80^{Cb}$ |
| | 30 | $2.25^{Aa}$ | $2.08^{Ba}$ | $1.74^{Ea}$ | $1.89^{Da}$ | $1.92^{Ca}$ |
| pH | 0 | $6.48^{Aa}$ | $6.46^{Bb}$ | $6.33^{Ea}$ | $6.43^{Ca}$ | $6.38^{Da}$ |
| | 7 | $6.27^{Bb}$ | $6.58^{Aa}$ | $6.25^{Cb}$ | $6.24^{Cb}$ | $6.12^{Db}$ |
| | 15 | $4.75^{Bc}$ | $4.74^{BCd}$ | $4.81^{Ac}$ | $4.73^{Cc}$ | $4.65^{Dc}$ |
| | 21 | $4.70^{Cc}$ | $4.76^{Bc}$ | $4.80^{Ac}$ | $4.65^{Dd}$ | $4.62^{Ed}$ |
| | 30 | $4.67^{Be}$ | $4.70^{Ae}$ | $4.49^{Dd}$ | $4.55^{Ce}$ | $4.56^{Ce}$ |
| S.N | 0 | $0.21^{Ac}$ | $0.18^{Bd}$ | $0.16^{Cd}$ | $0.18^{Be}$ | $0.10^{De}$ |
| | 7 | $0.21^{Ac}$ | $0.18^{Bd}$ | $0.21^{Ac}$ | $0.22^{Ad}$ | $0.19^{Bd}$ |
| | 15 | $0.24^{Ab}$ | $0.20^{Cc}$ | $0.25^{Bb}$ | $0.25^{Bc}$ | $0.25^{Bc}$ |
| | 21 | $0.38^{Aa}$ | $0.25^{Db}$ | $0.25^{Db}$ | $0.35^{Bb}$ | $0.28^{Cb}$ |
| | 30 | $0.38^{Aa}$ | $0.34^{Ba}$ | $0.34^{Ba}$ | $0.42^{Aa}$ | $0.35^{Ba}$ |
| TVFA | 0 | $18^{Ee}$ | $22^{Dd}$ | $24^{Ce}$ | $30^{Bc}$ | $36^{Ad}$ |
| | 7 | $20^{Ed}$ | $36^{Cc}$ | $34^{Dd}$ | $46^{Ab}$ | $42^{Bc}$ |
| | 15 | $24^{Dc}$ | $38^{Cb}$ | $38^{Cc}$ | $46^{Bb}$ | $66^{Ab}$ |
| | 21 | $34^{Eb}$ | $38^{Db}$ | $48^{Cb}$ | $58^{Ba}$ | $66^{Ab}$ |
| | 30 | $39^{Da}$ | $44^{Ca}$ | $58^{Ba}$ | $58^{Ba}$ | $76^{Aa}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

Table 5: Antioxidant activity of adding different *Moringa oleifera* oil concentration on chemical composition of labneh storage at 5±2°C for 30 days

| | Antioxidant activity (%) | |
|---|---|---|
| Treatments | Zero time | Thirty days |
| C1 | 5.96±0.85 | 1.57±0.74 |
| C2 | 5.19±0.23 | 1.35±0.30 |
| T1 | 14.37±0.39 | 7.71±0.07 |
| T2 | 17.27±0.62 | 10.34±0.22 |
| T3 | 20.60±0.70 | 14.27±0.15 |

C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

*Moringa oleifera* oil had excellent effect on the starter culture and total count during storage period that containing the high ratio of essential fatty acids. Changes in pH values of all treatments were contrary to that of acidity. Also, TVFA content increased in all treatments during storage period while the fortified labneh with high ratios of *Moringa oleifera* oil increased TVFA contents compared with control. The highest values were recorded with treatments fortified with 20%. The high total solids also increased the growth and activity of starter cultures as reported by Mahdian and Tehrani[41]. Furthermore, the SN content in all treatments increased by progress of storage period.

**Antioxidant activity of adding different *Moringa oleifera* oil concentration on chemical composition of labneh:** Data presented in Table 5 showed the content of antioxidant activity (DPPH%) of labneh fortified with different levels of *Moringa oleifera* oil when fresh and after 30 days of storage. Labneh fortified with high ratio of *Moringa oleifera* oil had the highest values of antioxidant activity compared to control samples and other treatments when fresh and after 30 days of storage. Antioxidant activities increased with increase of *Moringa oleifera* oil add while decreased after storage for 30 days but still higher than control. Generally, antioxidant activity improved with increasing of *Moringa oleifera* oil levels in labneh also after 30 days of storage. This due to the high levels of antioxidant activity in cold pressed *Moringa oleifera* oil that contain about 101.2 mM $kg^{-1}$ of oil DPPH scavenging activity (mmol TE $kg^{-1}$). As reported by Bhatnagar and Krishna[6] the crude seed oil from the Indian *Moringa oleifera* Jaffna variety, was high in omega-9 fatty acids (oleic acid) as presented in Table 2 and poor in PUFA contains surplus amounts of natural antioxidants and also exhibits better antiradical activity. *Moringa oleifera* oil its natural antioxidants and radical scavenging activity in comparison to other common vegetable oils[6].

**Vitamins content of labneh samples containing different concentration of *Moringa oleifera* oil:** Results in Table 6 show that the vitamins content of labneh which fortified with different ratios of *Moringa oleifera* oil. The concentration of water and fat soluble vitamins in labneh will reflect on the level of fat content in this product. The contents of B vitamins in labneh (22.5% fat) compared with (12.5% fat) decreased about thiamin 25% riboflavin 24% and niacin 56%; there were slight differences in pyridoxine and folic levels. Differences in levels concentrations of B vitamins in control samples were very negligible. Furthermore, phases of vitamin E content $\delta$, $\gamma$, $\alpha$-tocopherols in fortified labneh increased by increasing the addition level of *Moringa oleifera* oil and not detected in control samples. The increase in $\delta$, $\gamma$, $\alpha$-tocopherols content was due to the presence of higher concentrations of this vitamin in the oil of *Moringa oleifera* that content about 0.129, 0.461, 0.595 mg/100 g oil of the $\delta$, $\gamma$, $\alpha$ tocopherols, respectively. Thus these products considera great source of vitamin E.

Table 6: Vitamins content of labneh samples containing different concentration of *Moringa oleifera* oil

| | Water soluble vitamins (B) (mg/100 g) | | | | | Fat soluble vitamins (E) (mg/100 g) | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | B1 | B2 | B3 | B6 | B9 | δ-toco | γ-toco | α-toco |
| C1 | $0.141^{B}$ | $1.276^{B}$ | $0.079^{A}$ | $0.015^{A}$ | $0.0023^{A}$ | $0.00^{D}$ | $0.00^{D}$ | $0.00^{D}$ |
| C2 | $0.144^{A}$ | $1.298^{A}$ | $0.067^{B}$ | $0.015^{A}$ | $0.0024^{A}$ | $0.00^{D}$ | $0.00^{D}$ | $0.00^{D}$ |
| T1 | $0.106^{C}$ | $1.196^{C}$ | $0.053^{C}$ | $0.012^{B}$ | $0.0019^{B}$ | $0.023^{C}$ | $0.09^{C}$ | $0.121^{C}$ |
| T2 | $0.096^{D}$ | $0.905^{D}$ | $0.052^{C}$ | $0.011^{B}$ | $0.0018^{B}$ | $0.044^{B}$ | $0.130^{B}$ | $0.190^{B}$ |
| T3 | $0.084^{E}$ | $0.851^{E}$ | $0.044^{D}$ | $0.011^{B}$ | $0.0016^{C}$ | $0.057^{A}$ | $0.185^{A}$ | $0.250^{A}$ |

Data expressed as mean of 3 replicates±standard division. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labnehcheese with 20% *Moringa oleifera* oil

Table 7: Viability of *S. thermophilus* counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days

| | Treatments | | | | |
|---|---|---|---|---|---|
| Storage periods (days) | C1 | C2 | T1 | T2 | T3 |
| 0 | $7.35^{Bd}$ | $7.30^{Bd}$ | $7.40^{Ae}$ | $7.35^{Be}$ | $7.30^{Be}$ |
| 7 | $7.50^{Cc}$ | $7.60^{Bc}$ | $7.75^{Ad}$ | $7.80^{Ad}$ | $7.65^{Bd}$ |
| 15 | $7.73^{Db}$ | $7.85^{Db}$ | $8.00^{Cc}$ | $8.15^{Bc}$ | $8.30^{Ac}$ |
| 21 | $7.80^{Ea}$ | $8.00^{Da}$ | $8.30^{Cb}$ | $8.50^{Bb}$ | $8.70^{Ab}$ |
| 30 | $7.45^{Dc}$ | $7.90^{Ca}$ | $8.65^{Ba}$ | $8.90^{Aa}$ | $8.95^{Aa}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

**Viability of *S. thermophilus* counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days:** The effect of *Moringa oleifera* oil at different concentrations on growth of studied *S. thermophilus* counts in labneh samples during storage presented in Table 7. The growth of *S. thermophilus* counts was affected by *Moringa oleifera* oil. The obtained data revealed that increasing the concentration of *Moringa oleifera* oil from 10-20% led to increase the *S. thermophilus* during storage until the end of storage period. Also, the streptococci increased during storage especially in the samples that fortified with 20% which the initial count increased 1.65 $log_{10}$ CFU $g^{-1}$ after 30 days of storage and increased to 1.55 and 1.25 $log_{10}$ CFU $g^{-1}$ in the samples that fortified with 10 and 15%, respectively. In the contrary, the counts of *S. thermophilus* in control (C1) sample remained stable at the end of storage, but in control (C2) the count increased only 0.5 $log_{10}$ CFU $g^{-1}$. These results indicated that starter culture of labneh were able to grow in the essential fatty acid that found in *Moringa oleifera* oil. These results agree with Mohamed *et al.*[42]. Burt[43] found that Gram positive bacteria were able to grow in essential oil.

**Viability of *L. bulgaricus* counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days:** The same trend of results were observed in Table 8. The growth of *L. bulgaricus* counts was affected by *Moringa oleifera* oil. In our study found that the *L. bulgaricus* counts increased during storage with the increasing of the *Moringa oleifera* oil in labneh samples. The counts in samples that fortified with 20% increased 2.2 $log_{10}$ CFU $g^{-1}$ at the end of storage period, while the counts increased 2.09 and 1.75 $log_{10}$ CFU $g^{-1}$ in the samples that fortified with 10 and 15% after 30 days of storage. But, the control (C1) increased only less 0.5 $log_{10}$ CFU $g^{-1}$ after 30 days of storage. Kumalaningsih *et al.*[44] noted that the addition of *Moringa oleifera* extract increased the counts of lactic acid bacteria after 10 h from $10^3$-$10^8$ cells $mL^{-1}$ using MRS medium contained 8% *Moringa oleifera* extract. The presence of essential fatty and vitamins acid in the *Moringa oleifera* improved the growth of the organisms.

**Viability of *Lactobacillus acidophilus* counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days:** Viability of *Lactobacillus acidophilus* in labneh samples that fortified with different concentration of *Moringa oleifera* oil are shown in Table 9. The results demonstrated that, the treatment that fortified with 20% *Moringa oleifera* was contain the greatest numerous of *L. acidophilus* and followed with the other treatments comparing with the control (C1 and C2). Nevertheless, the differences between the treatments that fortified with *Moringa oleifera* oil were slight significant. On the other hand, differences tend to be significant among treatments during storage. The detected numerous of *L. acidophilus* log $_{10}$ CFU $g^{-1}$ were the highest at the end of storage period in all treatments especially, the treatments that contained 20 and 15% which the viable counts of *L. acidophilus* increased from 8.60-10.70 and from

Table 8: Viability of *L. bulgaricus* counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days

| | Treatments | | | | |
|---|---|---|---|---|---|
| Storage periods (days) | C1 | C2 | T1 | T2 | T3 |
| 0 | $7.00^{Cd}$ | $7.10^{BCe}$ | $7.25^{Ae}$ | $7.15^{Be}$ | $7.20^{Ae}$ |
| 7 | $7.25^{Bc}$ | $7.75^{Ad}$ | $7.85^{Ad}$ | $7.80^{Ad}$ | $7.75^{Ad}$ |
| 15 | $7.70^{Db}$ | $8.10^{Cc}$ | $8.30^{Bc}$ | $8.55^{Ac}$ | $8.40^{ABc}$ |
| 21 | $7.85^{Ca}$ | $8.40^{Bb}$ | $8.80^{Ab}$ | $8.90^{Ab}$ | $8.80^{Ab}$ |
| 30 | $7.20^{Ec}$ | $8.65^{Da}$ | $9.00^{Ca}$ | $9.20^{Ba}$ | $9.40^{Aa}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

Table 9: Viability of *Lactobacillus acidophilus* counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days

| | Treatments | | | | |
|---|---|---|---|---|---|
| Storage periods (days) | C1 | C2 | T1 | T2 | T3 |
| 0 | $8.10^{Cd}$ | $8.50^{ABe}$ | $8.45^{Be}$ | $8.50^{ABe}$ | $8.60^{Ae}$ |
| 7 | $8.25^{Cc}$ | $8.60^{Bd}$ | $8.90^{Ad}$ | $8.80^{Ad}$ | $8.95^{Ad}$ |
| 15 | $8.40^{Eb}$ | $9.25^{Dc}$ | $9.55^{Cc}$ | $9.70^{Bc}$ | $10.20^{Ac}$ |
| 21 | $8.90^{Da}$ | $9.60^{Cb}$ | $9.85^{Bb}$ | $9.90^{Bb}$ | $10.35^{Ab}$ |
| 30 | $8.80^{Ea}$ | $9.85^{Da}$ | $10.15^{Ca}$ | $10.30^{Ba}$ | $10.70^{Aa}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

8.50-10.30 $log_{10}$ CFU $g^{-1}$, respectively at 30 days of storage. But in the control (C1) the viable count of *L. acidophilus* slight decreased after 21 days of storage and reached to 8.80 $log_{10}$ CFU $g^{-1}$ at the end of storage. Hekmat *et al.*[45] showed that *Moringa oleifera* did not negatively affect on the growth of *Lactobacillus rhamnosus* GR-1 in MRS, milk or yogurt and the significant decrease was found after 5 weeks of storage at 4°C.

**Viability of total bacterial counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days:** The results in Table 10 showed the changes in total bacterial counts of different treatment of labneh during storage period. The results indicated that there is agradual increase was observed throughout the storage period in all labneh samples. The results indicate that the total bacterial counts were higher in labneh fortified with *Moringa oleifera* oil compared to controls (C1 and C2). The obtained results suggest that bacterial population was stimulated by adding oil of *Moringa oleifera.* This may be due to high nutritional composition of *Moringa oleifera* oil such as proteins, essential fatty acids, antioxidant and vitamins. Moreover, increases in the level adding *Moringa oleifera* oil led to enhance in bacterial counts. When added 20% led to increase the bacterial population more than 1.5 $log_{10}$ CFU $g^{-1}$ at the end of storage period but the bacterial population remain stable in the control (C1) after 30 days of storage. On the other hand, the high bacterial counts of such treatments may be due to increase the counts of starter cultures and probiotic bacteria that found in labneh samples. Our result confirmed by Barakat and Ghazal[46] indicated that *Moringa oleifera* oil contents high percentage in carotenoids, flavonoids and flavones contents. For that, the *Moringa oleifera* oil considered as a good source for dietary.

Table 10: Viability of total bacterial counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days

| | Treatments | | | | |
|---|---|---|---|---|---|
| Storage periods (days) | C1 | C2 | T1 | T2 | T3 |
| 0 | $8.00^{Cc}$ | $8.10^{Ce}$ | $8.30^{Be}$ | $8.40^{Ae}$ | $8.35^{ABe}$ |
| 7 | $8.10^{Eb}$ | $8.35^{Dd}$ | $8.50^{Cd}$ | $9.00^{Bd}$ | $9.30^{Ad}$ |
| 15 | $8.12^{Da}$ | $8.75^{Cc}$ | $8.80^{Cc}$ | $9.25^{Bc}$ | $9.50^{Ac}$ |
| 21 | $8.00^{Cc}$ | $9.00^{Bb}$ | $8.95^{Bb}$ | $9.55^{Bb}$ | $9.85^{Ab}$ |
| 30 | $8.05^{Ec}$ | $9.45^{Da}$ | $9.55^{Ca}$ | $9.80^{Ba}$ | $9.95^{Aa}$ |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

**Viable of mold and yeast counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days:** Mould and yeast counts are used to determine the quality and shelf life of labneh as in Table 11. In this study, moulds and yeasts counts were not observed in fresh labneh of all treatments and throughout the storage period. This may be due to *Moringa oleifera* oil had antimicrobial activities against wide range of pathogenic bacteria, mold and yeast. Other researchers reported that *Moringa oleifera* has been containing phenolic and flavonoid compounds that are responsible for their antimicrobial properties[47]. However, moulds and yeasts were detected in control after 15 days of storage period. The counts of mold and yeast reached to 2.55 and 10.50 $log_{10}$ CFU $g^{-1}$ in

the control (C1) and treatment that not fortified with *Moringa oleifera* oil, respectively at the end of storage and not detected any mold and yeast growth in other treatments fortified with different concentration of *Moringa oleifera* oil. Moreover, the labneh samples that fortified with different concentrations of *Moringa oleifera* oil remind safe from mold, yeast and coliform up to 30 days but the control become moldy after 15 days of storage, so the *Moringa oleifera* oil considered as a preservative agent can be used in different fermented products to extend the shelf life of this products. Our results agree with Salem *et al*.[48] indicated that yeast and mould were not detected in sour cream fortified with *M. oleifera* leaves extract and *Moringa oleifera* oil.

Notably, coliforms were not detected in fresh labneh and during storage period in all treatments, which indicated the good pasteurization and hygienic condition followed in its production.

**Texture profile analysis in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 15 days:** Data presented in Table 12 refers to rheological properties of fresh labenah and after 15 days of storage. Table 12 showed that hardness values were being the highest in the control treatment, decreased gradually by increasing the added ratios of *Moringa oleifera* oil to the labenah. The hardeness decreased with increase the add ratio from *Moringa oleifera* oil to record the lowest hardness with T3. These observations may be related to the ratio of T.S by Saad *et al*.[49] which being the highest in the control and has an effect on labneh hardens. The hardens slightly increased after 15 days storage, may be after 15 days the moisture content slightly decreased and T.S increased. Cohesivenes decreased with increase the *Moringa oleifera* oil added to the samples; the highest cohesivenes was noticed with C1 and C2 but lower cohesiveness observed at T3. After 15 days of storage cohesiveness increased could be also affected by to moisture, T.S and protein content that decreased by increase of oil amount to the samples. This results agreement with Saad *et al*.[49] who manufacture functional labneh using artichoke puree, UF-retentate and bifidobacteria and reported that moisture, T.S and protein content affected on cohesiveness and hardens.

Springiness also decreased with increasing *Moringa oleifera* oil added while decreased after 15 days storage. The high springiness value observed with C1 and C2. These could be related to the pH values and F/DM contents in control treatments as reported by Saad *et al*.[49]. Also, as presented in Table 12 gumminess and chewiness decreased with increase oil ratio, while decreased during storage time (15 days). Gumminess was decreased when protein content decreased and fat (*Moringa oleifera* oil) increased. Chewiness the energy required to chew a solid food to the point required for swallowing by Saad *et al*.[49] which means chewiness affected by T.S.

Table 11: Viable of mold and yeast counts ($Log_{10}$ CFU $g^{-1}$) in labneh samples containing different concentration of *Moringa oleifera* oil during storage at 5±2°C for 30 days

| | Treatments | | | | |
|---|---|---|---|---|---|
| Storage periods (days) | C1 | C2 | T1 | T2 | T3 |
| 0 | Nil | Nil | Nil | Nil | Nil |
| 7 | Nil | Nil | Nil | Nil | Nil |
| 15 | $1.40^{Ac}$ | $1.00^{Bc}$ | Nil | Nil | Nil |
| 21 | $2.00^{Ab}$ | $1.20^{Bb}$ | Nil | Nil | Nil |
| 30 | $2.55^{Aa}$ | $1.50^{Ba}$ | Nil | Nil | Nil |

Data expressed as mean of 3 replicates. Means in the same row showing the same capital letters are not significantly different ($p \leq 0.05$). Means in the same column showing the same small letters are not significantly different ($p \leq 0.05$). C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

Table 12: Rheological properties of labneh using different *Moringa oleifera* oil when fresh and after 15 days storage at 5±2°C

| Fresh samples | Storage time | Hardness N | Cohesivenes A area/B | Springiness Mm | Gumminess N | Chewiness M/N |
|---|---|---|---|---|---|---|
| C1 | Fresh | 7.4 | 0.692 | 0.811 | 1.984 | 2.212 |
| | 15 days | 7.5 | 0.702 | 0.764 | 2.492 | 1.381 |
| C2 | Fresh | 7.6 | 0.645 | 0.856 | 1.866 | 2.219 |
| | 15 days | 7.8 | 0.664 | 0.750 | 2.191 | 1.643 |
| T1 | Fresh | 3.6 | 0.602 | 0.685 | 6.737 | 4.615 |
| | 15 days | 4.1 | 0.627 | 0.657 | 7.464 | 2.932 |
| T2 | Fresh | 3.1 | 0.602 | 0.668 | 4.575 | 2.973 |
| | 15 days | 3.8 | 0.626 | 0.629 | 4.765 | 1.963 |
| T3 | Fresh | 2.4 | 0.591 | 0.650 | 2.322 | 1.321 |
| | 15 days | 3.1 | 0.620 | 0.604 | 2.693 | 1.454 |

C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*, T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

Table 13: Sensory properties of labneh with different concentration of *Moringa oleifera* oil during storage at 5±2°C at 30 days

| | | Treatments | | | | |
|---|---|---|---|---|---|---|
| Storage periods | Character assessed | C1 | C1 | T1 | T2 | T3 |
| Fresh | O. A. (10) | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ |
| | B and T (10) | $9.0^{A}$ | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ |
| | A and F (10) | $8.0^{A}$ | $8.0^{Aa}$ | $8.0^{Aa}$ | $8.0^{Aa}$ | $8.5^{Aa}$ |
| | T (30) | 26 | 26 | 26 | 26 | 26.5 |
| 7 days | O. A. (10) | $7.0^{Bb}$ | $8.0^{ABa}$ | $8.5^{ABab}$ | $9.0^{Aa}$ | $9.0^{Aa}$ |
| | B and T (10) | $8.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ | $9.0^{Aa}$ |
| | A and F (10) | $6.0^{Bb}$ | $8.0^{Aa}$ | $8.5^{Aa}$ | $8.5^{Aa}$ | $8.5^{Aa}$ |
| | T (30) | 21 | 25 | 26 | 26.5 | 26.5 |
| 15 days | O. A. (10) | $cont^{Bc}$ | $cont^{Bb}$ | $8.0^{Aab}$ | $8.5^{Aa}$ | $9.0^{Aa}$ |
| | B and T (10) | $cont^{Cc}$ | $cont^{Cb}$ | $8.0^{Bab}$ | $7.5^{ABab}$ | $8.5^{Aa}$ |
| | A and F (10) | $cont^{Cc}$ | $cont^{Cb}$ | $8.0^{Aa}$ | $8.5^{Aa}$ | $9.0^{Aa}$ |
| | T (30) | -- | -- | 24 | 25 | 26.5 |
| 21 days | O. A. (10) | $cont^{Cc}$ | $cont^{Cb}$ | $7.5^{Bb}$ | $8.0^{ABa}$ | $9.0^{Aa}$ |
| | B and T (10) | $cont^{Cc}$ | $cont^{Cb}$ | $7.0^{Bb}$ | $7.0^{Bb}$ | $8.5^{Aa}$ |
| | A and F (10) | $cont^{Bc}$ | $cont^{Bb}$ | $8.0^{Aa}$ | $8.0^{Aa}$ | $9.0^{Aa}$ |
| | T (30) | -- | -- | 22.5 | 23.5 | 26.5 |
| 30 days | O. A. (10) | $cont^{Cc}$ | $cont^{Cb}$ | $7.5^{Bb}$ | $8.0^{ABa}$ | $9.0^{Aa}$ |
| | B and T (10) | $cont^{Bc}$ | $cont^{Bb}$ | $7.0^{Ab}$ | $7.0^{Ab}$ | $8.0^{Aa}$ |
| | A and F (10) | $cont^{Cc}$ | $cont^{Cb}$ | $7.0^{Ba}$ | $8.0^{ABa}$ | $9.0^{Aa}$ |
| | T (30) | -- | -- | 21.5 | 23 | 26 |

O. A: Outer, B and T: Body and texture, A and F: Aroma and flavour, T: Total score, Cont: contamination with mold and yeast, C1: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures), C2: Labneh cheese without *Moringa oleifera* oil (containing only starter cultures+*L. acidophilus*), T1: Labneh cheese with 10% *Moringa oleifera* oil, T2: Labneh cheese with 15% *Moringa oleifera* oil and T3: Labneh cheese with 20% *Moringa oleifera* oil

**Sensory evaluation of labneh using different *Moringa oleifera* oil when fresh and during storage at 5±2°C at 30 days:** Data presented in Table 13 showed to sensory properties of labneh fortified with *Moringa oleifera* oil when fresh and after storage period. All treatment had same acceptability and sensory properties when fresh. Sensory properties of labneh using different *Moringa oleifera* oil slightly decreased during storage period. Control samples molded after 15 days of storage. Addition of *Moringa oleifera* oil to labneh using different concentration has no effect on the sensory properties or acceptability. The T3 considered the most acceptability treatment until the end of storage period compared with other treatments and control. Generally, addition of *Moringa oleifera* oil at different concentration to labneh improves the sensory properties, acceptability, extend the shelf life and nutrition values.

## CONCLUSION

*Moringa oleifera* oil contents high percentage of oleic acid, antioxidant activity and phenols contents. For that, the *Moringa oleifera* oil measured as a good source for dietary. Also, *Moringa oleifera* oil showed stronger antimicrobial activity against Gram-positive bacteria and Gram-negative bacteria more than mold and yeast. Moreover, fortified labneh with *Moringa oleifera* oil can be considered as a new product with functional properties, good acceptability, high nutritional value and extended the shelf life of this product.

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