Viability of Probiotic Strains in Moringa Aqueous Extract-Fortified Low-Fat Yogurt

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ABSTRACT: Advancements in the food industry and the growing consumer awareness of healthy and nutritive foods have led to an increased demand for functional foods. This study aims to enhance the properties and nutritional value of free fat Yogurt by fortifying it with moringa aqueous extract and lactic acid bacteria (LAB) probiotic strains. This study assessed the viability and bioactivity of four probiotic strains in yogurt fortified with moringa aqueous extract. All strains exhibited improved growth in the presence of moringa extract in a concentration-dependent manner. *Lactobacillus rhamnosus* (Lr-32) showed the highest growth rate, followed by *Lactobacillus plantarum* (Lp-115). *Lactobacillus acidophilus* (La-14) and *Lactobacillus casei* (Lc-11) had comparable growth profiles. Calculating Δ Log CFU g^{-1} revealed noticeable differences between samples with moringa extract and controls. Moringa enhanced probiotic viability, aligning with previous research attributing this to polyphenolic components in moringa. The yogurt's physio-chemical properties, including pH, titratable acidity, total solids, and moisture content, were investigated during 15 days of storage at 5 °C. pH gradually decreased during storage with moringa extract-treated samples. Titratable acidity and total solids increased slightly during storage, with the highest levels in moringa-treated samples. Sensory evaluation results were positive, moringa extract did not negatively impact colour, appearance, flavour, or texture. This suggests the potential for moringa extract as a valuable addition to low fat yogurt products without compromising sensory quality.

***Keywords**:* Moringa; Probiotic; Yogurt; Sensory evaluation; Physiochemical properties

INTRODUCTION

Progression within the food industry, coupled with an augmented consumer awareness concerning health-oriented and nutrient-laden dietary preferences, has engendered a marked escalation in the requisition for functional food items. In this context, dairy products hold a pronounced standing in the human diet, being acknowledged as all-encompassing sustenance replete with a comprehensive array of indispensable nutrients. The fermentation process, distinguished by its efficacy and economic feasibility, stands as a preeminent methodology for augmenting product functionality (Tamang, Shin, Jung, & Chae, 2016). There has been a tremendous increase in the production of fermented dairy products in the past few decades with their well-documented health benefits, which led the demand upwards (Gorlov et al., 2019; Lee, Cha, & Park, 2004). Prebiotics are the nonviable food components, mainly poly/oligosaccharides (inulin and its hydrolytic products, oligofructose, and galactooligosaccharides), which are selectively utilised by host microorganisms, thus, favoring/supporting the growth of probiotics in addition to other innate health effects (Davani-Davari et al., 2019; Gibson et al., 2017; Mohanty, Misra, Mohapatra, & Sahu, 2018). Various studies suggest the significance of synbiotic dairy foods incorporated with various probiotic bacteria and prebiotics (Li et al., 2020; Manoharan, Jayapratha, & Ashokkumar, 2020; Ranjitham & Poornakala, 2020). Bioactive chemicals are present in both plant- and animal-based origins. They have been investigated for use in creating functional synbiotic yogurt, including essential oils, honey, aloe vera, and moringa medicinal plant extracts (Ahmad et al., 2022).

Moringa (*Moringa oleifera)* is an ancient tree and one of 13 species in the *Moringaceae* family*;* it is the most well-known member of the genus. It is known as the drumstick tree or tree of life; the ability to utilize bark, pods, leaves, nuts, seeds, tubers, roots, and flowers of the plant makes it a multipurpose plant (Sacoto & Verlicchi, 2019). Moringa is known for its numerous nutritional and pharmacological activities, such as cardiac stimulants, antitumor agents, and may also have antioxidant, antihypertensive, anti-inflammatory, antibacterial and antifungal activities (Anwar, Latif, Ashraf, & Gilani, 2007). Moringa is a significant plant in the nutrition for people in many developing countries due to its substantial quantity of nutrients (Zhao et al., 2019). Moringa

is rich in several nutrients, such as proteins, fiber and minerals (Jongrungruangchok, Bunrathep, & Songsak, 2010; Moyo, Oyedemi, Masika, & Muchenje, 2012), that play an important role in human nutrition. It contains numerous phytochemicals (such as neochlorogenic acid, rutin, chlorogenic acid, apigenin, quercetin, and Kaempferol), as secondary plant metabolites having health-promoting effects, thereby reducing the risk of noncommunicable diseases (Lako et al., 2007; Scalbert, Johnson, & Saltmarsh, 2005). Formulations in the food industry, as the bioactive compounds studied in this plant can be included in foodstuff development (Saucedo-Pompa et al., 2018).

The leaves of moringa are the most nutritious vegetative part of the plant and an important source of B and C vitamins, provitamin A as beta-carotene, vitamin K, manganese, and protein (Adepoju & Selezneva, 2020; Peter, 2008). In addition, it has been shown to exhibit high antioxidant properties due to its polyphenol content (Shih, Chang, Kang, & Tsai, 2011; Sreelatha & Padma, 2009). Moringa leaves are of special interest for both physiological and microbial food preservation (Saucedo-Pompa et al., 2018). However, there are limitations on its consumption due to its greenish appearance and it slightly bitter and unpleasant taste (Adepoju & Selezneva, 2020). Therefore, the aim of the present study is to utilize the benefits of moringa leaves and overcome its unpalatable taste by using its aquas extract.

Recent studies have suggested incorporating plants and their extracts with probiotics to produce more effective and functional products (Allam M.G. & S.M., 2019; Chand et al., 2021; M. Gomaa, Alneamah, & Ayad, 2018; Mukprasirt, Domrongpokkaphan, Kaewpanya, Khemkhao, & Sumonsiri, 2022; Yilmaz et al., 2022). Adding plant extracts can enhance the growth of lactic acid bacteria and thus increase the beneficial effects on the human gastrointestinal tract (Burgain, Gaiani, Linder, & Scher, 2011; M. A. Gomaa, Allam, Haridi, Eliwa, & Darwish, 2022; Huq, Khan, Khan, Riedl, & Lacroix, 2013)**.** Moringa extract potentiated the LAB growth in the yogurt and attenuated the colon cancer by increasing the expression of antioxidant enzymes **(Zhang *et al.,* 2019).** In addition, it showed a protective effect against hepatic failure by enhancing the liver profile and lowering blood cholesterol levels **(Cardiens *et al,* 2018).**

Therefore, the aim of the present study is to produce a synbiotic yogurt that benefits from the lactic acid fermentation and phytochemistry of Moringa aqua extract. For this purpose, low-fat yogurt samples were prepared with different probiotic strains and enriched with different concentrations of Moringa aqua extract. The effect of the Moringa extract on the viability of the probiotics, the physicochemical properties of the yogurt, the sensory properties, and the shelf life of the product were evaluated.

MATERIALS AND METHODS

Milk preparation

Reconstituted low-fat bovine milk (0.5% fat,12% total solids, 3.37% protein, and 0.84% ash) was prepared from skimmed milk powder (RSM) for yogurt production.

Growth conditions of the starter culture and probiotic strains

pH-modified (4.58) MRS agar (Oxoid Ltd., Hampshire, England) (DeMan, Rogosa, & Sharpe, 1960) was used to count the commercial starter culture Yo-Mix® Real 300, containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *Bulgaricus* obtained from Danisco Denmark. Besides, the media were used to enumerate the four strains of probiotic LAB: *Lactobacillus rhamnosus* (Lr-32), *Lactobacillus casie* (Lc-11), *Lactobacillus acidophilus* (La-14), and *Lactobacillus plantarum* (Lp-115), which were obtained from the culture collection of Danisco (California Gold Nutrition). All bacteria were incubated at 42 °C for 72 h.

Moringa aqueous extract

Fresh Moringa leaves (*Moringa oleifera*) were obtained from the farm of the Faculty of Agriculture Saba Basha, Egypt. The leaves were soaked in cold water at 5 ℃ for three min to remove impurities. Subsequently, the leaves were dehydrated in an oven at 55℃ for 16-18 h. The dried leaves were crushed into fine powder using a food processor (Tornado FP-1000SG, Egypt), sieved through a 60 mm mesh sieve, and stored at -20 °C until use.

The aqueous Moringa extract was prepared by mixing 40 g of the dried leaf powder in 100 mL of distilled water at 40°C for 24 h with shaking at 12 rpm. Afterwards, the extract was filtered twice with Whatman filter paper No. 1 and stored at -20°C until use (**Arif et al., 2022)**.

Moringa aqueous extract effect on strains viable count

The number of viable bacteria was determined for each strain in a pH-modified (4.58) MRS broth supplemented with Moringa aqua extract at four concentrations (0.0, 0.5, 1.0, or 1.5%). The broth media were incubated with 0.1 mL of an overnight growth culture. Samples were collected in triplicate at seven time points (0, 4, 8, 12, 16, 20, and 24 h) of growth at 42 °C. Each sample

was diluted up to 10-8 in MRS broth, then plated on MRS agar and counted under the same conditions for 48 hours. The number of viable bacteria was then recorded as Log CFU g^{-1}.

Yogurt manufacture

The yogurt was produced by lactic acid fermentation of reconstituted low-fat bovine milk heat-treated at 80°C for 10 minutes. Either the commercial starter culture Yo-Mix® Real 300 or one of the four strains of probiotic LAB was added: *Lactobacillus rhamnosus* (Lr-32), *Lactobacillus casie* (Lc-11), *Lactobacillus acidophilus* (La-14) and *Lactobacillus plantarum* (Lp-115) to reach 10^8 cfu/mL in the final mixture at 42 ºC and mixed well. The inoculated milk was supplemented with Moringa aqua extract (0.5%, 1%, or 1.5%) in addition to the controls (0.0) (Table 1), then filled into 100 ml cups and incubated at 42ºC for about 3h, followed by cooling at 4°C. The synbiotic yogurt preparations were stored at 5 °C for 15 days for further experiments (**Tamime & Robinson, 2007)**.

pH, acidity, and viscosity determination

The pH values of the yogurt samples were measured with a pH meter (Jenway 3505, England). The acidity of the yogurt samples was determined by direct titration with 0.11 molar NaOH, and the values were calculated as lactic acid (%) according to equation (1) (**Llanos et al., 2019)**. The test was repeated four times over a period of 15 days at 1, 5, 10, and 15 days of storage. The viscosity of the yogurt treatments was measured at 15 °C using a viscometer (D.P. SELECTA, S.A. ST-2020R, Korea) at a speed of 60 to 200 rpm with spindle R5. The viscosity is expressed in mPa·s. and the temperature is automatically corrected **(Kia, Ghasempour, Ghanbari, Pirmohammadi, & Ehsani, 2018).**

$$\text{Acidity}(\%) = \frac{\text{Volume of NaOH} \times \text{Normality of NaOH} \times 0.09 \times 100}{\text{Sample weight}} \quad (1)$$

Yogurt's microbial viable counts during storage

One gram of low-fat yogurt was mixed in 9 mL of phosphate buffer, 1 mL of which was transferred to the appropriate agar medium and counted. Plates were incubated at 37°C for 48 hours (for all bacteria) and counts were expressed as log CFU g^{-1}. LAB were counted on MRS agar. Coliform bacteria were counted on Violet red bile agar (VRBA). Yeasts and molds were counted on potato dextrose agar for 7 days at 25°C (**Kazama, 2020).** The test was repeated four times during the 15-day storage period: on the 1st, 5th, 10th, and 15th day.

Probiotic count and specific growth rate

For counting LAB, the MRS agar (Biolife) was used as recommended by the Standard Methods for examination of dairy Products. The plates were incubated for 48 h at 37 ºC.

Table 1: The formulation of twelve synbiotic low-fat yogurt trials and the control

Trial	Culture	Moringa aqueous extract (v/v%)
Control	Yo-Mix® Real 300	0.0%
MA0	*Lb. acidophilus* (La-14)	0.0 %
MA1	*Lb. acidophilus* (La-14)	0.5%
MA2	*Lb. acidophilus* (La-14)	1.0%
MA3	*Lb. acidophilus* (La-14)	1.5%
MP 0	*Lb. plantarum* (Lp-115)	0.0%
MP 1	*Lb. plantarum* (Lp-115)	0.5%
MP2	*Lb. plantarum* (Lp-115)	1.0%
MP3	*Lb. plantarum* (Lp-115)	1.5%
MC0	*Lb. casei* (Lc-11)	0.0%
MC1	*Lb. casei* (Lc-11)	0.5%
MC2	*Lb. casei* (Lc-11)	1.0%
MC3	*Lb. casei* (Lc-11)	1.5%
MR.0	*Lb. rhamnosus* (Lr-32)	0.0%
MR.1	*Lb. rhamnosus* (Lr-32)	0.5%
MR2	*Lb. rhamnosus* (Lr-32)	1.0%
MR3	*Lb. rhamnosus* (Lr-32)	1.5%

Sensory evaluation of synbiotic yogurt

Nine experienced panelists, consisting of staff from the Faculty of Agriculture, Saba Basha, Alexandria University, aged 24–61 years, participated in the evaluation of the sensory attributes of fermented milk samples one day after production. Low fat yogurt samples (100 mL cups) were placed on white plates and randomly presented to the panelists. The panelists were asked to evaluate the sensory characteristics of the

yogurt (color, flavour, appearance, and texture) on a 5-point scale (with 1 being the worst and 5 being the best).

First, the color was evaluated in contrast to the white paper in the background. Second, the flavour (smell and taste) was evaluated by swallowing ≈10 g (one spoon portion) of the sample. Appearance was assessed by visual observation, and finally, textural properties were assessed by breaking the yogurt gel and shaking the product. Overall acceptability was assessed at the end of the sensory evaluation of each sample **(Soukoulis, Panagiotidis, Koureli, & Tzia, 2007).**

Statistical analysis

Data were analyzed using one-way ANOVA with IBM SPSS 25 (Armonk, New York, United States); the obtained data were expressed as mean ± standard deviation (SD). Differences between means from one-way ANOVA were compared using Duncan's test at a 95% confidence level ($p < 0.05$).

RESULTS AND DISCUSSION

Probiotic strains viability

Viability of the four selected probiotic strains Lactobacillus *rhamnosus* (Lr-32), *Lactobacillus casie* (Lc-11), *Lactobacillus acidophilus* (La-14) and *Lactobacillus plantarum* (Lp-115) were assessed in MRS media supplemented with Moringa water extract at 0.5%, 1%, 1.5% v/v or 0.0% as control. At seven intervals of growth development (0, 4, 8, 12, 16, and 24 h), the number of viable microorganisms was presented as Log CFU g^{-1} ± SD in Table 2 and as Δ Log CFU g^{-1} in Figure 1.

All strains showed better growth in the presence of the aqueous Moringa extract, depending on the concentration. The highest value was recorded for *Lactobacillus rhamnosus* (Lr-32), which generally showed a higher growth rate in general and the trial MR3, 1290 ±0.01 log CFU $g^{-1} \times 10^6$, followed by MR2 and MR1, and the lowest count for this strain was observed in MR0, where no aqueous Moringa extract was added (1170 ±0.02, 1020 ±0.02, and 296 ±0.02 log CFU $g^{-1} \times 10^6$, respectively). The second-best performance was observed for *Lactobacillus plantarum* (Lp-115), with the trials containing aqueous moringa extract ranging from 430±0.03 to 300±0.02 Log CFU $g^{-1} \times 10^6$, corresponding to an increase of 35-117% in viable count compared to the control MP0, which recorded 184 ±0.03 Log CFU $g^{-1} \times 10^6$. *Lactobacillus acidophilus* (La-14) and *Lactobacillus casei* (Lc-11) probiotic strains showed a comparable viable count profile, with values ranging from 199 ±0.03 to 267 ±0.03 for the trials containing 0.5%, 1%, 1.5% v/v moringa aqueous extract (MA1, MA2, MA3, MC1, MC2, and MC3). While the controls (MA0, and MC0) recorded 174 ±0.03 and 181 ±0.01 Log CFU $g^{-1} \times 10^6$, respectively.

The calculation of Δ Log CFU g^{-1} shows a higher contrast when comparing samples containing aqueous Moringa extract with controls and eliminates the inoculum effect, as shown in Figure 1. *Lactobacillus plantarum* (Lp-115), which showed the second highest growth among all strains, presented a limited difference between all trials (MR1, MR2, MR3) and the control MR0, which started to be noticeable after 12 hours of growth. *Lactobacillus acidophilus* (La-14) performed better in the higher concentrations of moringa aqueous extract of 1% and 1.5% (MA2 and MA3) since the first reading. A limited improvement was observed at 0.5% (MA1), which was close to the control MA0. The probiotic strains *Lactobacillus rhamnosus* (Lr-32) and *Lactobacillus casei* (Lc-11) shared a similar growth profile in which the addition of moringa aqueous extract at all concentrations posted the viable count upwards after 12 and 8 hours. The final Δ Log CFU g^{-1} of MR3 was almost 10 times higher than the viable count of control (MR0). A similar trend was observed in the case of *Lactobacillus casei* (Lc-11); the highest moringa extract concentration in MC3 increased the viable count by 2.5 times the control MC0.

Table 2: Bacterial viable count of probiotic strains: *Lactobacillus acidophilus* (La-14), *Lactobacillus plantarum* (Lp-115), *Lactobacillus casei* (Lc-11), and *Lactobacillus rhamnosus* (Lr-32) in moringa aqueous extract-Fortified MRS media continuing 0.5%, 1%, 1.5% v/v or 0.0% as control

Strain	Treatment	0 h	4 h	8 h	12 h	16 h	20 h	24 h
Lactobacillus acidophilus (La-14)	**MA0**	101.00 ±0.05^{bcd}	109.00 ±0.03^{cd}	124.00 ±0.03^{d}	132.00 ±0.02^{bc}	149.00 ±0.03^{c}	162.00 ±0.03^{c}	174.00 ±0.03^{d}
	MA1	101.00 ±0.04^{ab}	123.00 ±0.01^{cd}	148.00 ±0.02^{abc}	162.00 ±0.02^{abc}	170.00 ±0.04^{c}	189.00 ±0.04^{c}	199.00 ±0.03^{cd}
	MA2	101.00 ±0.05^{ab}	130.00 ±0.03^{bc}	154.00 ±0.01^{abc}	178.00 ±0.02^{ab}	182.00 ±0.02^{c}	196.00 ±0.01^{c}	286.00 ±0.04^{cd}
	MA3	101.00 ±0.03^{ab}	136.00 ±0.04^{bc}	163.00 ±0.03^{abc}	179.00 ±0.04^{ab}	185.00 ±0.03^{c}	203.00 ±0.02^{c}	289.00 ±0.05^{cd}
Lactobacillus plantarum (Lp-115)	**MP0**	10.90 ±0.05^{cd}	11.10 ±0.03^{bc}	13.50 ±0.03^{d}	23.20 ±0.02^{abc}	29.70 ±0.05^{c}	176.00 ±0.04^{c}	184.00 ±0.03^{d}
	MP1	10.90 ±0.03^{d}	12.30 ±0.05^{bc}	15.90 ±0.02^{d}	190.00 ±0.05^{abc}	268.00 ±0.02^{c}	291.00 ±0.03^{c}	300.00 ±0.02^{cd}
	MP2	10.90 ±0.04^{d}	12.90 ±0.01^{ab}	16.50 ±0.03^{d}	201.00 ±0.03^{ab}	277.00 ±0.02^{bc}	297.00 ±0.01^{c}	400.00 ±0.04^{cd}
	MP3	10.90 ±0.04^{d}	13.80 ±0.04^{ab}	17.40 ±0.03^{d}	216.00 ±0.02^{a}	286.00 ±0.01^{bc}	299.00 ±0.01^{c}	430.00 ±0.03^{bc}
Lactobacillus casie (Lc-11)	**MC0**	22.00 ±0.01^{b}	23.60 ±0.03^{cd}	24.40 ±0.04^{d}	26.30 ±0.02^{abc}	29.10 ±0.02^{c}	69.00 ±0.04^{c}	181.00 ±0.01^{cd}
	MC1	22.00 ±0.02^{b}	25.90 ±0.01^{cd}	26.50 ±0.02^{d}	28.20 ±0.01^{c}	45.00 ±0.04^{c}	89.00 ±0.04^{c}	209.00 ±0.02^{c}
	MC2	22.00 ±0.03^{b}	27.00 ±0.02^{bc}	27.00 ±0.03^{d}	29.00 ±0.02^{c}	60.00 ±0.03^{c}	115.00 ±0.04^{c}	246.00 ±0.02^{c}
	MC3	22.00 ±0.02^{b}	27.30 ±0.01^{ab}	28.80 ±0.01^{d}	29.70 ±0.04^{abc}	81.00 ±0.01^{c}	138.00 ±0.03^{c}	267.00 ±0.03^{c}
Lactobacillus rhamnosus (Lr-32)	**MR0**	168.00 ±0.03^{b}	170.00 ±0.03^{ab}	184.00 ±0.01^{bcd}	197.00 ±0.05^{ab}	270.00 ±0.02^{c}	281.00 ±0.02^{c}	296.00 ±0.02^{cd}
	MR1	168.00 ±0.02^{a}	176.00 ±0.05^{a}	191.00 ±0.01^{ab}	214.00 ±0.02^{a}	800.00 ±0.02^{b}	940.00 ±0.05^{b}	1020.00 ±0.02^{b}
	MR2	168.00 ±0.02^{a}	183.00 ±0.05^{a}	207.00 ±0.05^{ab}	222.00 ±0.02^{a}	930.00 ±0.05^{b}	1080.00 ±0.04^{a}	1170.00 ±0.02^{a}
	MR3	168.00 ±0.04^{a}	189.00 ±0.02^{a}	220.00 ±0.02^{a}	236.00 ±0.02^{a}	1010.00 ±0.02^{a}	1160.00 ±0.03^{a}	1290.00 ±0.01^{a}

All numbers are presented as Log CFU g-1 × 10^6 ± SD

Data with different superscript lowercase letters in the same columns are statistically different ($p < 0.05$)

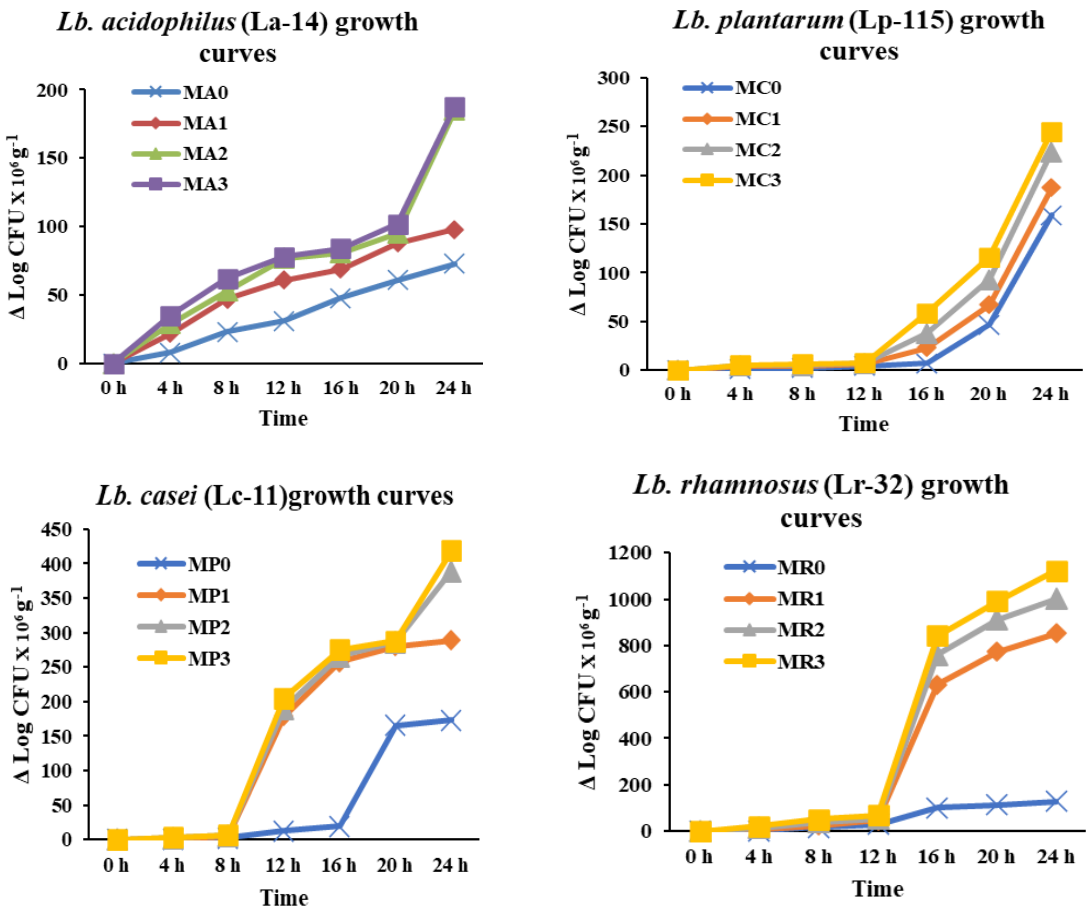

Figure 1: Bacterial viable counts of probiotic strains: *Lactobacillus acidophilus* (La-14), *Lactobacillus plantarum* (Lp-115), *Lactobacillus casei* (Lc-11), and *Lactobacillus rhamnosus* (Lr-32) in moringa aqueous extract-Fortified MRS media continuing 0.5%, 1%, 1.5% v/v or 0.0% as control all numbers are presented as Δ Log CFU g-1 × 10^6.

Physio-Chemical properties of moringa Yogurt

pH and acidity

Table 3 illustrates the pH values of the Yogurt samples. The highest pH value was observed in the control sample after one day of storage (4.64), which gradually decreased to 4.42 at the end of the 15-day of storage period. The lowest pH value was noticed in MC3 (1.5% moringa aqueous extract) with *Lactobacillus casei* (Lc-11), with 4.41, 4.30, 4.14, and 4.07 after 1, 5, 10 and 15 days of storage at 5°C, respectively. Overall, a concentration-dependent decrease in pH was observed in all treatments throughout the storage period. This decrease is attributed to the conversion of lactose into lactic acid, indicating higher activity in the presence of the aqueous extract. This pH decrease signifies the continuous growth of lactic acid culture during storage, which is enhanced by the presence of moringa aqueous extract. Similar results have been reported in other studies, where yogurt supplemented with moringa exhibited a significant reduction in pH compared to control samples (El-Gammal, Abdel-Aziz, & Darwish, 2017; Saeed, 2020).

Similar to the pH trend, a slight increase was also observed in the total titratable acidity. The highest values were recorded in trial MC3 with titratable acidity values of 0.79, 0.80, 0.81, and 0.82% after 1, 5, 10, and 15 days of storage at 5°C, respectively. This increase was dependent on the concentration of the aqueous Moringa extract. Conversely, the lowest titratable acidity was observed in the control sample with values of 0.60, 0.69%, 0.73, and 0.78% at the same storage intervals. The increase in acidity is due to bacterial activity converting lactose into organic acids, mainly lactic acid, resulting in a decrease in pH. This trend is consistent with previous reports Asfour and Anwer (2015)

Total solids

The addition of moringa to yogurt treatments increased the total solids content in a concentration-dependent manner. The highest total solids content was found in treatment MR3 (1.5% moringa aqueous extract) with *Lactobacillus rhamnosus* (Lr-32), measuring 12.39, 12.43, 12.46, and 12.51% ± 0.1 after 1, 5, 10 and 15 days of storage at 5 °C, respectively. The lowest value was observed in the fresh control sample at 12.22% ± 0.1. A slight increase in total solids was observed during storage in most trials, including the control (Table 3). The highest moisture content was observed in the fresh control sample at 87.78%, while the lowest content was observed in treatment MR3 (1.5% moringa aqueous extract). The slight variation in moisture content may be attributed to storage at low humidity conditions, which is consistent with the findings of I. Bakr, Mohamed, Tammam, and El-Gazzar (2015) and A. Bakr, Mousa, and EL-Shahawy (2020).

Viscosity

Viscosity significantly influences the quality of liquid and semi-solid foods (Karaman et al., 2014). The control's viscosity increased during the 15-day storage period. In all treatments, the addition of moringa aqueous extract led to an increase in viscosity, in contrast to the 0% trials (MA0, AP0, MC0, and MR0), and this increase was concentration-dependent. On the first day of storage, the highest viscosity value was 44.2 ± 2.57 mPa.s in the MR3 treatment with *Lb. rhamnosus*. The viscosity gradually decreased during storage to reach 40.8 ± 1.74, 33.4 ± 3.27, and 26 ± 1.66 after 5, 10, and 15 days of storage at 5°C, respectively. Similar trends were observed in all trials, with an overall decrease in viscosity during storage. All strains were in the same range as the commercial starter culture, aligning with the findings of Vital et al. (2015) and Zhang et al. (2019), who attributed increased yogurt viscosity with moringa extract to protein-polyphenol interactions. Moringa contains abundant polyphenolic compounds that can form complexes with milk proteins, such as casein.

Table 3: pH, acidity, and total solids (Ts) of 16 low fat yogurt trials 12 of which are fortified by moringa aquas extract 0.5, 1.0, and 1.5 % during storage for 15 days at 5°C presented as value ± SD.

Trial	pH				Acidity%				Total solids %			
	Storage period (days)											
	1	5	10	15	1	5	10	15	1	5	10	15
Control	4.64 ±0.00^{a}	4.56 ±0.00^{b}	4.51 ±0.01^{a}	4.42 ±0.02^{a}	0.60 ±0.01^{e}	0.69 ±0.02^{c}	0.73 ±0.01^{d}	0.78 ±0^{bcd}	12.22 ±0.01^{f}	12.26 ±0.01^{d}	12.35 ±0.00^{d}	12.38 ±0.00^{d}
MA0	4.56 ±0.01^{a}	4.44 ±0.01^{b}	4.36 ±0.00^{ab}	4.27 ±0.01^{a}	0.70 ±0.00^{abcd}	0.75 ±0.00^{bc}	0.78 ±0.00^{abcd}	0.805 ±0.01^{abc}	12.26 ±0.02^{ef}	12.295 ±0.01^{cd}	12.37 ±0.01^{cd}	12.40 ±0.01^{cd}
MA1	4.47 ±0.02^{abcd}	4.31 ±0.00^{a}	4.20 ±0.01^{abcd}	4.11 ±0.00^{abcd}	0.79 ±0.00^{ab}	0.80 ±0.02^{ab}	0.82 ±0.01^{ab}	0.83 ±0.00^{ab}	12.29 ±0.02^{cdef}	12.33 ±0.01^{bcd}	12.38 ±0.01^{bcd}	12.42 ±0.01^{bcd}
MA2	4.44 ±0.01^{bcd}	4.30 ±0.00^{b}	4.18 ±0.01^{cde}	4.13 ±0.01^{bcd}	0.76 ±0.00^{a}	0.80 ±0.00^{ab}	0.82 ±0.01^{ab}	0.82 ±0.02^{a}	12.31 ±0.02^{cdef}	12.35 ±0.01^{abc}	12.39 ±0.00^{bcd}	12.44 ±0.00^{abcd}
MA3	4.45 ±0.01^{cd}	4.30 ±0.02^{b}	4.12 ±0.00^{def}	4.09 ±0.02^{cd}	0.76 ±0.01^{a}	0.80 ±0.01^{ab}	0.83 ±0.01^{a}	0.83 ±0.01^{a}	12.33 ±0.01^{abcde}	12.37 ±0.01^{ab}	12.41 ±0.01^{abc}	12.47 ±0.01^{abc}
MP0	4.6 ±0.01^{abcd}	4.48 ±0.01^{b}	4.44 ±0.02^{abcd}	4.39 ±0.01^{abcd}	0.69 ±0.02^{abc}	0.74 ±0.01^{abc}	0.77 ±0.02^{ab}	0.8 ±0.00^{ab}	12.26 ±0.01^{def}	12.3 ±0.01^{abc}	12.37 ±0.01^{abc}	12.41 ±0.02^{abcd}
MP1	4.56 ±0.01^{ab}	4.40 ±0.01^{b}	4.37 ±0.01^{ab}	4.36 ±0.02^{a}	0.78 ±0.02^{abcd}	0.79 ±0.02^{abc}	0.80 ±0.02^{ab}	0.82 ±0.00^{ab}	12.3 ±0.02^{cdef}	12.34 ±0.00^{bcd}	12.39 ±0.01^{bcd}	12.44 ±0.00^{abcd}
MP2	4.52 ±0.01^{abcd}	4.39 ±0.00^{b}	4.37 ±0.01^{abc}	4.33 ±0.01^{a}	0.78 ±0.02^{a}	0.79 ±0.02^{ab}	0.81 ±0.00^{ab}	0.82 ±0.02^{a}	12.35 ±0.00^{abcd}	12.36 ±0.01^{abc}	12.4 ±0.01^{abc}	12.46 ±0.02^{abc}
MP3	4.53 ±0.02^{abcd}	4.42 ±0.00^{b}	4.35 ±0.02^{abc}	4.30 ±0.02^{ab}	0.78 ±0.01^{a}	0.79 ±0.00^{ab}	0.81 ±0.01^{ab}	0.82 ±0.02^{ab}	12.37 ±0.02^{ab}	12.39 ±0.01^{ab}	12.42 ±0.02^{ab}	12.49 ±0.01^{a}
MC0	4.54 ±0.01^{abcd}	4.42 ±0.01^{b}	4.32 ±0.01^{abcd}	4.26 ±0.01^{abc}	0.70 ±0.02^{a}	0.77 ±0.01^{abc}	0.79 ±0.01^{abc}	0.81 ±0.01^{ab}	12.24 ±0.00^{abcd}	12.27 ±0.01^{bcd}	12.38 ±0.01^{abc}	12.40 ±0.02^{abc}
MC1	4.44 ±0.01^{abcd}	4.27 ±0.01^{b}	4.12 ±0.01^{abcd}	4.10 ±0.01^{abcd}	0.80 ±0.00^{a}	0.84 ±0.02^{ab}	0.84 ±0.01^{ab}	0.84 ±0.01^{a}	12.26 ±0.00^{def}	12.28 ±0.01^{cd}	12.38 ±0.01^{bcd}	12.42 ±0.01^{bcd}
MC2	4.42 ±0.01^{d}	4.25 ±0.01^{b}	4.14 ±0.01^{bcde}	4.08 ±0.01^{cd}	0.79 ±0.01^{a}	0.80 ±0.00^{ab}	0.80 ±0.01^{ab}	0.81 ±0.00^{a}	12.31 ±0.01^{cdef}	12.34 ±0.01^{bcd}	12.39 ±0.01^{bcd}	12.46 ±0.00^{abcd}
MC3	4.41 ±0.01^{d}	4.30 ±0.01^{b}	4.14 ±0.01^{f}	4.07 ±0.02^{d}	0.79 ±0.00^{a}	0.80 ±0.00^{ab}	0.81 ±0.02^{ab}	0.82 ±0.01^{ab}	12.36 ±0.01^{abc}	12.38 ±0.02^{ab}	12.42 ±0.02^{abc}	12.48 ±0.01^{ab}
MR0	4.61 ±0.02^{abcd}	4.48 ±0.00^{b}	4.44 ±0.01^{ef}	4.39 ±0.00^{abcd}	0.62 ±0.02^{abcd}	0.72 ±0.01^{abc}	0.74 ±0.02^{abcd}	0.765 ±0.01^{abc}	12.26 ±0.01^{abcd}	12.305 ±0.00^{abc}	12.37 ±0.01^{abc}	12.41 ±0.00^{abcd}
MR1	4.58 ±0.02^{a}	4.40 ±0.00^{b}	4.37 ±0.01^{ab}	4.36 ±0.01^{a}	0.64 ±0.01^{cd}	0.75 ±0.01^{bc}	0.75 ±0.00^{bcd}	0.75 ±0.01^{cd}	12.3 ±0.02^{cdef}	12.35 ±0.02^{bcd}	12.39 ±0.01^{bcd}	12.43 ±0.02^{abcd}
MR2	4.60 ±0.01^{a}	4.43 ±0.02^{b}	4.38 ±0.00^{abc}	4.37 ±0.02^{a}	0.61 ±0.00^{de}	0.68 ±0.02^{bc}	0.69 ±0.01^{d}	0.70 ±0.02^{d}	12.35 ±0.01^{abcd}	12.39 ±0.02^{ab}	12.41 ±0.01^{abc}	12.45 ±0.01^{abcd}
MR3	4.53 ±0.00^{abc}	4.36 ±0.02^{b}	4.34 ±0.01^{abcd}	4.33 ±0.01^{a}	0.68 ±0.02^{bcd}	0.75 ±0.01^{bc}	0.75 ±0.00^{cd}	0.76 ±0.00^{d}	12.39 ±0.01^{a}	12.43 ±0.01^{a}	12.46 ±0.01^{a}	12.51 ±0.02^{a}

All numbers are presented as mean ± SD

Data with different superscript lowercase letters in the same columns are statistically different ($p < 0.05$)

Table 4: Viscosity averages mPa.s ± SD of 16 low fat yogurt trials 12 of which are fortified by moringa aquas extract 0.5, 1.0, and 1.5 % during storage for 15 days at 5 °C.

	Storage period (days)			
Trial	**1**	**5**	**10**	**15**
Control	21.23 ±3.58^{c}	21.54 ±1.70^{c}	21.82 ±2.30^{ab}	22.40 ±3.11^{b}
MA0	23.32 ±2.20^{c}	23.37 ±2.54^{c}	22.91 ±3.31^{ab}	23.10 ±1.53b^{b}
MA1	25.40 ±1.30^{c}	25.20 ±3.07^{bc}	24.00 ±2.81^{ab}	23.80 ±1.50 ^{b}
MA2	28.00 ±1.72^{bc}	27.60 ±1.33^{abc}	26.10 ±2.91^{a}	25.70 ±2.93 ^{b}
MA3	33.10 ±2.71^{abc}	32.50 ±1.98^{abc}	32.10 ±1.90^{a}	31.00 ±1.88 ^{b}
MP0	24.12 ±2.33^{abc}	23.42 ±3.65^{abc}	23.01 ±2.63^{a}	22.70 ±2.37 ^{b}
MP1	27.00 ±1.84c	25.30 ±1.28^{bc}	24.20 ±3.45^{ab}	23.00 ±1.87 ^{b}
MP2	30.10 ±2.58^{abc}	29.80 ±2.96^{abc}	27.00 ±1.34^{a}	23.10 ±2.33 ^{b}
MP3	36.40 ±1.23^{abc}	34.20 ±3.66^{abc}	30.10 ±2.97^{a}	28.70 ±3.65 ^{b}
MC0	24.27 ±3.06^{abc}	23.27 ±2.26^{abc}	22.96 ±3.19^{a}	21.90 ±3.21 ^{b}
MC1	27.30 ±2.51^{bc}	25.00 ±2.89^{bc}	24.10 ±1.20^{ab}	21.40 ±1.87 ^{b}
MC2	33.10 ±1.65^{abc}	30.40 ±3.63^{abc}	29.10 ±2.09^{a}	27.00 ±2.49 ^{b}
MC3	39.20 ±2.68^{ab}	35.70 ±1.61^{ab}	33.00 ±2.96^{a}	31.30 ±3.31 ^{b}
MR0	24.62 ±1.73^{abc}	23.77 ±3.28^{abc}	22.96 ±2.95^{a}	21.35 ±1.78 ^{b}
MR1	28.00 ±3.47^{bc}	26.00 ±3.40^{bc}	24.10 ±3.33^{ab}	20.30 ±1.42^{a}
MR2	33.10 ±3.21^{abc}	30.40 ±2.34^{abc}	28.90 ±1.89^{b}	26.00 ±3.42 ^{b}
MR3	44.20 ±2.57^{a}	40.80 ±1.74^{a}	33.40 ±3.27^{a}	26.00 ±1.66 ^{b}

All numbers are presented mean ± SD
Data with different superscript lowercase letters in the same columns are statistically different ($p < 0.05$)

Microbial analysis of yogurt

Table 5 displays the probiotic viability values for the control and trial yogurt samples during the 15-day of storage period at 5 °C. The data show that increasing the level of moringa aqueous extract fortification in yogurt led to an increase in the viable probiotic counts. The highest count value was recorded in the MR3 treatment with *Lb. rhamnosus*, measuring 940 ± 5, 800 ± 5, 760 ± 10, and 480 ± 7 Log CFU $g^{-1} \times 10^{6}$ on days 1, 5, 10, and 15 of storage, respectively. This indicates that the yogurt with the highest moringa extract concentration exhibited the maximum probiotic viability, in agreement with Zhang et al. (2019), who reported higher viable cell counts in moringa aqueous extract-supplemented yogurt compared to the control. They also suggested that the increased growth of lactic acid bacteria could be attributed to the polyphenolic components of moringa extract, as Moringa oleifera contains dietary polyphenolic substances (Siddhuraju & Becker, 2003), which may promote fermentation rates and enhance lactic acid bacteria metabolism and survival.

The yeast and mold count of control and treatments exhibited no significant difference that agreement with (Rupa & Vijay, 2022). The coliforms were found to be absent in both control and treatment yogurt samples, which confirms that the product has been produced under hygienic standards.

Table 5: Bacterial viable counts of probiotic strains: *Lactobacillus acidophilus (La-14),Lactobacillus plantarum* (Lp-115), *Lactobacillus casei* (Lc-11), and *Lactobacillus rhamnosus* (Lr-32) in moringa aqueous extract-Fortified low-fact yogurt continuing 0.5, 1, 1.5% (v/v) or 0.0% as control.

	Storage period (days)			
Trial	**1**	**5**	**10**	**15**
Control	95 ±10^{d}	64 ±9^{d}	44 ±11^{e}	33 ±11^{d}
MA0	128 ±9^{d}	110 ±10^{d}	88 ±4^{e}	79 ±3^{d}
MA1	160 ±9^{d}	155 ±3^{d}	132 ±9de	124 ±8^{cd}
MA2	280 ±7^{cd}	215 ±8^{cd}	201 ±5de	178 ±10^{bcd}
MA3	280 ±6^{cd}	215 ±3^{cd}	201 ±3^{cde}	178 ±4^{bcd}
MP0	153 ±9^{cd}	135 ±10^{cd}	122 ±3de	76 ±7^{cd}
MP1	211 ±7^{d}	206 ±7^{cd}	199 ±6de	119 ±9^{cd}
MP2	460 ±10^{cd}	380 ±3^{cd}	370 ±11^{bcde}	294 ±4^{bcd}
MP3	490 ±11^{bc}	400 ±6^{cd}	390 ±6^{cd}	297 ±4^{ab}
MC0	162 ±4^{cd}	143 ±9^{cd}	119 ±10^{bcde}	108 ±3^{bcd}
MC1	228 ±4^{d}	221 ±11^{cd}	193 ±7de	182 ±8^{bcd}
MC2	410 ±9^{cd}	390 ±5$^{b\ cd}$	310 ±5^{bcde}	291 ±3^{bc}
MC3	410 ±8^{bcd}	390 ±5^{bc}	310 ±6^{bcd}	291 ±6^{ab}
MR0	268 ±7^{cd}	187 ±5^{bcd}	165 ±5$^{bcd\ e}$	141 ±9^{bcd}
MR1	440 ±7^{bcd}	310 ±10^{bcd}	286 ±10^{bcde}	249 ±8^{bcd}
MR2	920 ±3^{ab}	780 ±8^{b}	530 ±4^{b}	330 ±3^{ab}
MR3	940 ±5^{a}	800 ±5^{a}	760 ±10^{a}	480 ±7^{a}

All numbers are presented as Log CFU g-1 × 10^{6} ± SD.
Data with different superscript lowercase letters in the same columns are statistically different ($p < 0.05$)

Sensory evaluation

The sensory evaluation results of the yogurt samples, in which attributes such as color, appearance, flavor, and texture, are presented in Figure 2. The radar charts depict the average sensory scores for sixteen different low-fat yogurt treatments fortified with moringa aqueous extract. Data revealed that there was a ±1 difference observed between all treatments and the control for all parameters, except for texture, where the control was the softest, with a score of 3.

All samples exhibited a normal white color similar to the control, indicating that the addition of moringa aqueous extract did not affect the natural color of the products. Samples containing *Lactobacillus plantarum* (MP0, MP1, MP2, MP3) were slightly preferred, possibly due to a starter culture effect, as one of the trials contained 0% moringa extract (MP0). Additionally, the flavor of samples containing *Lactobacillus plantarum* (MP0, MP1, MP2, MP3) and *Lactobacillus rhamnosus* (MR0, MR1, MR2, MR3) was similar to the control and received the highest scores.

Regarding appearance, all trials produced normal and homogeneous yogurt products. However, nine samples scored one point higher than the control. Among these, four contained *Lactobacillus rhamnosus* as a starter culture (MR0, MR1, MR2, MR3), three contained *Lactobacillus casei* (MC0, MC1, MC2), and the last two were fermented using *Lactobacillus acidophilus*.

In terms of texture, the control was softer than all trials. Nevertheless, samples containing *Lactobacillus plantarum* (MP0, MP1, MP2, MP3) and *Lactobacillus rhamnosus* (MR0, MR1, MR2, MR3) as a starter culture received the maximum score, while the other two strains scored four points.

Despite the light greenish color and slightly bitter taste of the moringa extract, all sensory scores for yogurt with moringa aqueous extract were very positive. The addition did not affect the color, smooth appearance, flavor, or texture of the products. These findings contrast with prior studies by Saeed (2020) and Rupa and Vijay (2022), which reported a reduction in body and texture when moringa leaf powder was introduced into functional Greek yogurt. Moreover, the incorporation of moringa extract in our study did not result such negative attributes.

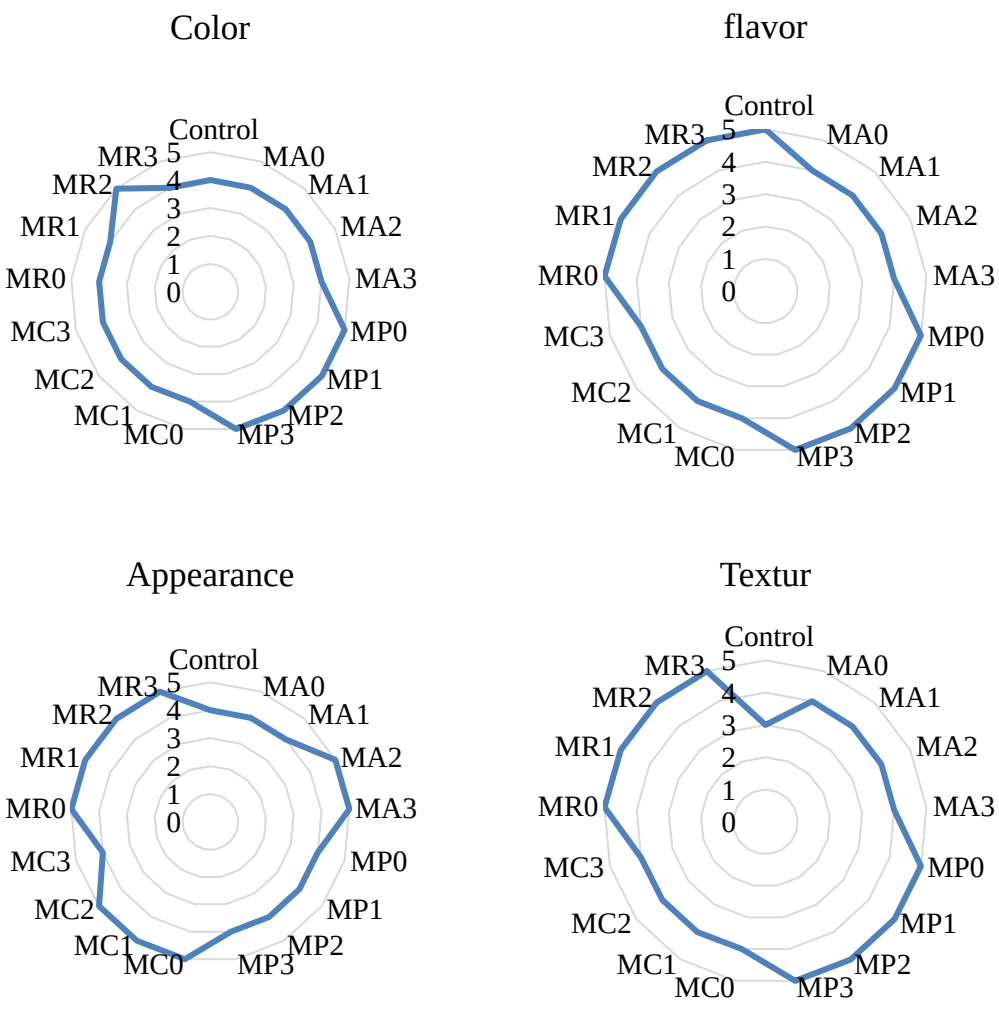

Figure 2: Sensory evaluation of sixteen different moringa aqueous extract-fortified low-fat Yogurt treatments containing probiotic strain as a starter culture: *Lactobacillus acidophilus (La-14)*, *Lactobacillus plantarum* (Lp-115) (MP0, MP1, MP2, MP3), *Lactobacillus casei* (Lc-11) (MC0, MC1, MC2), and *Lactobacillus rhamnosus* (Lr-32) (MR0, MR1, MR2, MR3) in four levels each (0.0, 0.5%, 1%, or 1.5% v/v) in addition to the control.

CONCLUSION

This study revealed that the addition of moringa aqueous extract positively influenced the viability and bioactivity of probiotic strains in low fat yogurt, with notable improvements in growth rates, particularly for *Lactobacillus rhamnosus* (Lr-32) and *Lactobacillus plantarum* (Lp-115). This enhancement is attributed to the polyphenolic compounds present in moringa extract, offering the potential for tailored probiotic formulations to meet specific health and nutritional goals. Moringa extract supplementation led to changes in yogurt's physio-chemical properties, including a reduction in pH and an increase in titratable acidity, and total solids. Despite moringa's light greenish color and slight bitterness, sensory evaluation confirmed that moringa extract did not compromise the overall sensory quality of yogurt. The product retained its natural colour, appearance, flavour, and texture, suggesting that moringa can be integrated into a new low-fat probiotic Yogurt formulation without negatively impacting consumer acceptability but with good Microbial viability and numerous therapeutic potentials.

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الملخص العربي

حيوية بعض سلالات البروبيوتيك في الزبادي قليل الدسم المدعم بمستخلص المورينجا

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أدى التقدم في صناعة الأغذية، إلى جانب زيادة وعي المستهلك فيما يتعلق بالتفضيلات الغذائية الموجهة نحو الصحة والمحملة بالمغذيات، إلى تصاعد ملحوظ في طلب المواد الغذائية الوظيفية. وفي هذا السياق، تتمتع منتجات الألبان بمكانة واضحة في النظام الغذائي البشري، حيث يتم الاعتراف بها باعتبارها مصدر رزقشامل وغني بمجموعة شاملة من العناصر الغذائية التي لا غنى عنها. تعتبر عملية التخمير، التي تتميز بفعاليتها وجدواها الاقتصادية، بمثابة منهجية بارزة لزيادة وظائف المنتج . هناك زيادة هائلة في إنتاج منتجات الألبان المخمرة في العقود القليلة الماضية مع فوائدها الصحية الموثقة جيدًا والتي أدت إلى ارتفاع الطلب . البريبايوتك هي مكونات غذائية غير قابلة للحياة بشكل رئيسي السكريات المتعددة/قليلة التعدد (الإينولين ومنتجاته المحللة، قليل الفركتوز، والسكريات قليلة التعدد)، والتي تستخدم بشكل انتقائي بواسطة الكائنات الحية الدقيقة المضيفة، وبالتالي، تفضل/تدعم نمو البروبيوتيك بالإضافة إلى التأثيرات . تشير دراسات مختلفة إلى أهمية أطعمة الألبان التكافلية المدمجة مع العديد من البكتيريا البروبيوتيك والبريبايوتكس . المواد الكيميائية النشطة بيولوجيا موجودة في كل من الأصول النباتية والحيوانية. لقد تم فحصها لاستخدامها في صنع الزبادي الوظيفي، بما في ذلك الزيوت العطرية والعسل والصبار ومستخلصات نباتات المورينجا الطبيه .

تم عمل الدراسه بكليه الزراعه سابا باشا جامعه الاسكندريه

تهدف هذه الدراسة إلى تعزيز الخصائص والقيمة الغذائية للزبادي خالي الدسم من خلال تدعيمه بمستخلص المورينجا وسلالات البروبيوتيك المختاره. قيمت هذه الدراسة الجدوى والنشاط الحيوي لأربعة سلالات بروبيوتيك في الزبادي المدعم بمستخلص المورينجا . أظهرت جميع السلالات نمواً جيدا بوجود مستخلص المورينجا اعتمادا على التركيز. أظهرت Lactobacillus rhamnosus (Lr–32)أعلى معدل نمو، تليها .Lactobacillus plantarum (Lp–115) كان لدى Lactobacillus acidophilus (La–14) و Lactobacillus casei (Lc–11)ملامح نمو مماثلة. مع وجود اختلافات ملحوظة بين العينات التي تحتوي على مستخلص المورينجا وعينه التحكم. عززت المورينجا صلاحية البروبيوتيك، بما يتماشى مع الأبحاث السابقة التي تنسب ذلك إلى مكونات البوليفينول في المورينجا.

تم دراسة الخصائص الفيزيائية والكيميائية للزبادي، بما في ذلك الرقم الهيدروجيني والحموضة القابلة للمعايرة والمواد الصلبة الكلية ومحتوى الرطوبة خلال 15 يومًا من التخزين عند درجة حرارة 5 درجات مئوية.

المورينجا (Moringa oleifera) هي شجرة قديمة وواحدة من 13 نوعًا في عائلةMoringaceae ؛ إنه العضو الأكثر شهرة في الجنس. وتُعرف باسم شجرة الطبل أو شجرة الحياة؛ إن القدرة على الاستفادة من اللحاء والقرون والأوراق والمكسرات والبذور والدرنات والجذور وأزهار النبات تجعله نباتًا متعدد الأغراض . تشتهر المورينجا بأنشطتها الغذائية والدوائية العديدة مثل منشطات القلب والعوامل المضادة للأورام، وقد تحتوي أيضًا على أنشطة مضادة للأكسدة وخافضة للضغط ومضادة للالتهابات ومضادة للبكتيريا ومضادة للفطريات . تعتبر المورينجا نباتًا مهمًا في تغذية الأشخاص في العديد من البلدان النامية، نظرًا لكميتها الكبيرة من العناصر الغذائية . المورينجا غنية بالعديد من العناصر الغذائية مثل البروتينات والألياف والمعادن والتي تلعب دورًا مهمًا في تغذية الإنسان. وهو يحتوي على العديد من المواد الكيميائية النباتية (مثل حمض النيكلوروجينيك، والروتين، وحمض الكلوروجينيك، والأبيجينين، والكيرسيتين، والكايمبفيرول)، باعتبارها مستقلبات نباتية ثانوية لها تأثيرات تعزز الصحة و حيث يمكن إدراج المركبات النشطة بيولوجيًا التي تمت دراستها في هذا النبات في تطوير المواد الغذائية

اقترحت الدراسات الحديثة دمج النباتات ومستخلصاتها مع البروبيوتيك لإنتاج منتجات أكثر فعالية . يمكن أن تؤدي إضافة المستخلصات النباتية إلى تعزيز نمو بكتيريا حمض اللاكتيك وبالتالي زيادة التأثيرات المفيدة على الجهاز الهضمي البشري . عزز مستخلص المورينجا نمو LAB في الزبادي وتخفيف سرطان القولون عن طريق زيادة التعبير عن الإنزيمات المضادة للأكسدة . بالإضافة إلى ذلك، فقد أظهر تأثيرًا وقائيًا ضد الفشل الكبدي من خلال تعزيز صورة الكبد وخفض مستويات الكوليسترول في الدم.

لذلك، فإن الهدف من هذه الدراسة هو إنتاج زبادي معزز يستفيد من تخمر حمض اللاكتيك والكيمياء النباتية لمستخلص المورينجا . ولهذا الغرض، تم تحضير عينات الزبادي قليل الدسم باستخدام سلالات بروبيوتيك مختلفة وتدعيمها بتركيزات مختلفة من مستخلص

المورينجا . تم تقييم تأثير مستخلص المورينجا على صلاحية البروبيوتيك، والخصائص الفيزيائية والكيميائية للزبادي، والخصائص الحسية والعمر الافتراضي للمنتج.

أهم النتائج:

1-أظهرت جميع السلالات نمواً أفضل بوجود مستخلص المورينجا اعتماداً على التركيز. تم تسجيل أعلى قيمة لبكتيريا Lactobacillus rhamnosus (Lr-32) .

2- تم تقدير الرقم الهيدروجيني لعينات الزبادي. وقد لوحظت أعلى قيمة للرقم الهيدروجيني في عينة التحكم بعد يوم واحد من التخزين (4.64)، والتي انخفضت تدريجياً إلى 4.42 في نهاية فترة التخزين البالغة 15 يوماً. ولوحظت أقل قيمة للأس الهيدروجيني في MC3 (1.5% مستخلص من المورينجا) مع(Lactobacillus casei (Lc-11 ، مع .، بعدو15 يومًا من التخزين عند درجة حرارة 5 درجات مئوية . وبشكل عام، لوحظ انخفاض في درجة الحموضة بزياده التركيز في جميع المعاملات طوال فترة التخزين.

3-أدت إضافة المورينجا إلى عينات الزبادي إلى زيادة محتوى المواد الصلبة الكلية بزياده التركيز. تم العثور على أعلى محتوى إجمالي للمواد الصلبة في المعالجة MR3 (1.5% مستخلص مائي من المورينجا) مع(Lactobacillus rhamnosus (Lr-32 ، . وقد لوحظت زيادة طفيفة في إجمالي المواد الصلبة أثناء التخزين في معظم العينات.

4- زادت لزوجة عنصر التحكم خلال فترة التخزين خلال 15 يومًا. في جميع المعاملات، أدت إضافة مستخلص للمورينجا إلى زيادة اللزوجة،

5- العددالكلي للبروبيوتيك في عينات الزبادي خلال فترة التخزين 15 يومًا عند 5 درجات مئوية. تشير البيانات إلى أن زيادة تركيز مستخلص المورينجا في الزبادي أدى إلى زيادة في أعداد البروبيوتيك . تم تسجيل أعلى قيمة عددية MR3 بـLb. rhamnosus ،

6-أظهرت جميع العينات لوناً أبيض عادياً مشابهاً للتحكم، مما يدل على أن إضافة مستخلص المورينجا لم يؤثر على اللون الطبيعي للمنتجات.

7-جميع النتائج الحسية للزبادي بمستخلص المورينجا كانت إيجابية للغاية. ولم تؤثر الإضافة على لون المنتجات أو مظهرها الناعم أو نكهتها أو ملمسها.

التوصيات:

نشير إلى أنه يمكن دمج المورينجا في تركيبة زبادي بروبيوتيك جديدة قليلة الدسم دون التأثير سلبًا على قبول المستهلك ولكن على قابلية البقاء الميكروبية الجيدة والإمكانات العلاجية العديدة.