Production of Synbiotic Labneh Using Papaya's Pulp Fibers Powder and Probiotic Bacteria

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ABSTRACT

This study explores the production of symbiotic labneh incorporating papaya pulp fiber powder (PPFP) and probiotic bacteria. Labneh was prepared with varying concentrations of PPFP (0%, 0.5%, 1.5%, 2%, 2.5%, and 3%) and 15% papaya juice. The samples were stored in a refrigerator for 28 days and assessed at intervals of 7, 14, 21, and 28 days. Results demonstrated that PPFP supplementation significantly ($P \leq 0.05$) increases titratable acidity, carbohydrates, T.S., ash, total phenolics and antioxidant activity, but had no effect on protein and fat content. By elongation the storage period there was no significant effect on T.S. , protein and fat in all treatments, while decreasing pH values ($P \leq 0.05$). By increasing the PPFP percentage T.C., Lactobacilli count, Streptococci count and Bifidobacteria count increased significantly ($P \leq 0.05$), but Bifidobacteria count decreased during the storage. Mold and yeast were not detected along the storage period. Sensory evaluation indicated that PPFP-enriched labneh is a promising vehicle for delivering probiotics at high concentrations 10^5 – 10^7CFU

Keywords: Labneh, papaya's pulp fibers powder, papaya juice, bioactive compounds, Bifidobacteria.

INTRODUCTION

Certain foods have been recognized for their potential health benefits. Functional foods have emerged as a type of food, or food ingredient, that goes beyond basic nutrition value and has positive effects on the health and well-being of the consumer. One prominent example of this category is fermented milk with probiotic bacteria as highlighted by Rogelj (2000).

Labneh, also known as strained or concentrated yogurt, which is considered one of the traditional fermented dairy products, is widely consumed around the world especially in the Middle East, Turkey and Balkan regions. It holds a significant role in the family diet, and has gained popularity over the last years due to perceived nutritional benefits and storage characteristics. However, consumer acceptance of labneh largely depends on its organoleptic properties, which are highly influenced by the processing method used (Shamsia & El-Ghannam, 2012). Labneh is characterized by its creamy or white color, soft and smooth texture, good spreadability, little syneresis, clean flavor, and weak acidity. It is believed to possess similar or even surprised nutritional and therapeutic properties compared to regular yogurt. Studies have shown that labneh contains 2.5 times more protein, 50% more minerals and a much higher number of living microorganisms than traditional yoghurt (Rocha *et al.,* 2014).

Dietary fiber is refers to the parts of plant or similar carbohydrates that cannot be digested and absored in the small intestine humans. Instead ,they either complete or partial fermentation in the large intestine (AACC, 2000).This includes cellulose, non-cellulosic polysaccharides like hemicellulose, gums, pectic substances, mucilages and a non-carbohydrate component called lignin. Natural sources of dietary fiber include vegetables, fruits, cereals, and nuts (Dhingra *et al.,* 2012). Enriching dairy products with soluble dietary fiber can turn them into functional foods. The addition of fiber helps improvement the sensory characteristics, shelf life and structural properties of dairy products such as texture, viscosity, and their ability to hold oil and water (Ambuja & Rajakumar, 2018).

Papaya pulp and peel contain dietary fiber and antioxidants. Research has shown that around 65% of the polyphenols present in the pulp and peel can be absorbed by small intestine, while the indigestible fibrous fraction still retain antioxidant properties. The dietary fiber can be used as a functional ingredient to prevent lipid oxidation and meet the growing demand for health promoting foods (Nieto-Calvache *et al*., 2016). Furthermore, papaya is nutrient dense food, providing a higher concentration of nutrients per calorie compared to other foods. It contains various bioactive phytochemicals with different structures and functions that have yet to be fully explored for their potential health benefits. Papaya contains carotenoids, flavonoids and polyphenols. It contains a significant amount of beta-carotene, which the body converts to vitamin A. In fact, papaya contains approximately 6% of the beta-carotene level found in carrots (USDA, 2006). Papaya is a highly beneficial fruit that is packed with dietary fiber, making it an effective remedy for preventing constipation. Additionally, the fiber content in papaya can help to lower high blood cholesterol levels.Furthermore, Papaya can fulfill 100%. daily vitamin C requirement and provide 30% of vitamin A needs. It is also in addition contains small quantities of vitamin K, E, riboflavin, thiamine, pyridoxine ,niacin, and folate. Folic acid, is needed for the conversion of homocysteine in the blood to cysteine and methionine. Elevated levels of homocysteine in blood are considered a significant risk factor for a heart attack or strokes as they directly damage the blood vessel walls (Antoniades *et al*., 2009, Seo *et al*., 2010).

Probiotic have beneficial effect on the health of consumers by maintaining or improving their gut microbial balance (Fuller, 1989, FAO/WHO, 2001). As a result, probiotic are increasingly being included in yoghurt and fermented milks due to their health benefits. The benefits of probiotics include the prevention of diarrhea caused by certain pathogenic bacteria and viruses, intestinal syndromes and inflammatory diseases, colon cancer, mucosal immunity, constipation, allergies, cardiovascular disease, urogenital genitourinary disorders, urinary tract infections, and *Helicobacter pylori* infection and complications. Probiotics may also reduce their long-term risk of kidney, respiratory and heart diseases (Parvez *et al*., 2006). Bifidobacteria has nemerous benefits to human health, such as immuno-stimulation (Dong *et al.,* 2010), cholesterol reduction (Ziarno *et al*., 2007), synthesis of vitamins (Crittenden *et al.,* 2003, Beitane & Ciprovica, 2011), prevention of infectious diarrhea (Qiao *et al.,* 2002), lactose hydrolysis (He *et al.,* 2007) and break down sugars and produce organic acids (Russell *et al.,* 2011). This means that people with lactose intolerance and hypercholesterolemia can consume dairy products. Additionally, the growth of Bifidobacteria can be promoted with addition of prebiotics (Rastall & Maitin, 2002).

The main objective of this study was to assess the feasibility of producing a high quality symbiotic labneh by incorporating papaya's pulp fibers powder and probiotic bacteria. Additionally, the study aimed to track the alterations in labneh's quality characteristics and viability of probiotic bacteria throughout the storage duration.

MATERIALS AND METHODS

Materials:

Fresh bulk buffalo milk has the following composition: 6.2% fat, 16.56% total solids, 4.58% protein, 0.92% ash, 0.18% acidity, and pH 6.63 was obtained from the herd of the Faculty of Agriculture, Menoufia University, Shibin El. Kom, Egypt. The bacterial strains used in the study, including *Streptococcus thermophiles* (EMCC 1043), *Lactobacillus delbrueckii subsp. bulgaricus* (EMCC 1102) and *Bifidobacteriumbifidum* (DSM 20082) were obtained from Cairo Mircen, Ain Shams University, Egypt. Papaya's fruits were obtained from the El-Salam Farm, Sadat, Egypt.

Methods:

Bacterial strains and propagation:

Bifidobacterium bifidum was activated through three successive transfers in modified MRS broth medium (Ventling & Misty 1993). This was followed by three successive transfers in sterile 10% reconstituted non-fat dry milk and incubated at 37ºC under anaerobic condition. *Streptococcus thermophiles* and *Lactobacillus delbrueckii subsp. Bulgaricus* were activated individually through three successive transfers in sterile 10% reconstituted non-fat dry milk.

Preparation of papaya's juice(PJ) and papaya's pulp fibers powder (PPFP):

Ripe papaya fruits were sorted and washed with tap water. The fruits were peeled by knife and the edible portion (pulp) was carefully separated. The papaya juice was filtered through a clean cheese cloth and heat treated at 95ºC for 15 minutes. Afterward, The juice was cooled and stored in sterilized bottle until ready for use (Matter *et al*., 2016). The remaining pomace was washed with distilled water, pressed and dried at 55ºC±2 using an air oven for 18 hours (Fernandez-Lopez *et al*., 2004). The dried pomace was then ground carefully to pass through a 80 mesh sieve to obtain papaya's pulp fibers powder (PPFP). The obtained powder was packed in sterile bags, and stored in a refrigerator at (6ºC±1) until analysis and use. The chemical composition of thepapaya juice and papaya's pulp fibers powder are shown in Table (1).

Manufacture of labneh:

Labneh was manufactured using traditional methods according to Tamime & Robinson (1999) with some modifications. Fresh buffalo's milk was standardized to 5.5% fat, heated at 90ºC for 15 min. Papaya's juice was added to heated milk at a rate of 15% (Roy *et al*., 2015). The mixture was then cooled to 42ºC and inoculated with 1.5% of the yoghurt starter, which consisted of 0.75% *Streptococcus thermophiles* + 0.75% *Lactobacillus delbrueckii* subsp. *bulgaricus.* Additionally,1.5% of *Bifidobacteriumbifidum*was added. The mixture was incubated at 42ºC until complete coagulation occurred. After coagulation, the fermented milk was cooled to 6ºC±1 overnight. It was then placed into cheese cloth bags, and hang in the a refrigerator at 6°C±1 for 12 hrs to allow whey drainage. The resulting product, labneh was divided into seven batches (C, T_1, T_2, T_3, T_4, T_5 and T_6). Papaya pulp fibers powder was added to each batch at varying rates (zero, 0.5, 1, 1.5, 2, 2.5 and 3%, respectively). The fresh labneh was thoroughly mixed and packed into 100gm plastic cups. It was then stored at 6ºC±1 for 28 days. Throughout the storage period, samples were taken from each labneh treatment every week for evaluation of chemical, microbiological and organoleptic properties.

Chemical analysis:

The fat content of papaya's pulp fibers powder samples was determined using Soxhlet extraction and the dietary fiber content of the samples was determined by acid-base digestion. Total solids, ash content and total protein content were determined as described in AOAC (2010). For the determination of pH value, acidity and fat content in milk and labneh refer to Ling (2008). The percentage of Carbohydrates was calculated using the following formula: Carbohydrates (%) = Total solids (%) – [fat (%) + protein (%) + ash (%)]. The total phenolic content was determined using the Folin–Ciocalteu micro-method according to Allam *et al*. (2015). The antioxidant activity was determined by 2,2-diphenyl-1-picryl-hydrazine (DPPH) radical scavenging activity as stated by Tepe *et al.,* (2005). All tests were performed in triplicate.

Microbiological tests:

The total number of bacteria was determined using nutrient agar and incubated at 37ºC for 48 hours,following the method described by Difco, (1971). Streptococci was enumerated on M17 agar medium, and the plates were incubated at 37ºC for 48 hours following the method by Terzaghi & Sandine, (1975). Lactobacilli was enumerated on MRS agar medium and the plates were incubated at 37ºC for 48 hours following the method by Deman *et al*. (1960). Bifidobacteria count was determined using modified MRS agar medium as described by Ventling & Mistry, (1993). Before pouring the plates, 5.0 ml of the following solution were added to each 100 ml of modified MRS medium, following the method of Samona & Robinson, (1991).

a. Neomycinesulphate 0.8% w/v.
b. Paromycinesulphate 0.2% w/v.
c. Nalidixic acid 0.3% w/v.
d. Lithium chloride 6%.

Table 1 :The chemical composition of papaya juice and papaya's pulp fibers powder.

Components	Papaya'sjuice(%)	Papaya's pulp fibers powder(%)
Total solids	13.87	92.64
Protein	0.65	2.83
Fat	0.41	1.09
Ash	0.84	1.79
Total carbohydrate	11.97	86.93 (Total dietary fiber 58.42)
Antioxidant activity	76.15	83.63
Total phenolic compounds	243.60 (mg gallic acid/100 g)	320.18 (mg gallic acid/100 g)

Plates were incubated under anaerobic condition at 37ºC for 72 hours.

Yeast and mold were counted on acidified potato dextrose agar medium. Plates were incubated at 25ºC for 5 days, following the guidelines of APHA (2005).

Sensory evaluation:

The organoleptic properties of labneh treatments were evaluated by a panel of ten individuals consisting of staff members and graduate students at the Department of Dairy Science and Technology and Department of Food Science and Technology, Faculty of Agriculture, Menoufia University. Scored values for flavor (60 points), body and texture (30 points) and appearance (10 points) as outlined by Salem (2007).

Statistical analysis:

Data were analyzed using a completely randomized block design and a 2 × 3 factorial design. The Newman-Keuls test was used for multiple comparisons using the Costat procedure (Steel & Torrie, 1980). Significant differences were identified at ($P \leq 0.05$).

RESULTS AND DISCUSSION

Chemical composition

The chemical composition of labneh treatments including titratable acidity, pH value, and total solids is shown in Table (2). The results indicate that the addition of papaya's pulp fiber powder (PPFP) significantly ($P\leq$ 0.05) increased the titratable acidity of labneh (Manzoor *et al.,* 2019). These results could be attributed to the stimulating effect of PPFP on the growth of bacteria and subsequently developing of labneh acidity. The stimulating effect of PPFP on the growth of bacteria might be due to the higher fermentable carbohydrate and minerals and/or higher dietary fibers, which act as prebiotic (Hussein *et al*., 2020, Mojikon *et al.,* 2022). Furthermore, there was a significant ($P\leq$ 0.05) increase in titratable acidity of all labneh treatments as storage period progressed (Othman *et al*., 2019, Mpopo *et al*., 2020). This can be attributed to the continued metabolism of lactic acid bacteria and the progressive transformation of carbohydrates into lactic acid during refrigerated storage (Ramirez-Santiago *et al*., 2010). In contrast, the pH of labneh followed an opposite trend to acidity as reported by Manzoor *et al*. (2019).

Addition of PPFP to labneh treatments led to a significant ($P\leq$ 0.05) increase in total solids. However, total solids percentage of l labneh treatments remained unchanged during the refrigerated storage period, with no significant ($P\leq$ 0.05) differences observed. These results are similar to those of Meenakshi *et al.* (2018) and Balabanova *et al.* (2020).

Supplementation of labneh treatments with PPFP have no significant (P>0.05) impact on the fat and protein contents as shown in Table (3). This lack of effect may be attributed to the low fat and protein contents of PPFP as reported by Pavithra *et al*. (2017) and Nieto-Calvache *et al*. (2018). Also, fat and protein contents of labneh treatments didn't differ significantly (P> 0.05) during the storage period. These results are in accordance with those reported by Habib *et al*. (2017) and Balabanova *et al*. (2020).

Ash content of all treatments slightly increased by supplementing with PPFP (Table 3). Labneh treatments (T2, T3, T4, T5 and T6), which were made by adding 1.0, 1.5, 2.0, 2.5 and 3.0% PPFP, respectively did not show significant difference (P≤0.05) among each other, however, T6 has a significant (P≤0.05) difference from both control and T1 treatments. This may be due to the high ash content of PPFP. The ash content of labneh treatments increased slightly during refrigerated storage period Similar results were obtained by Atallah (2016) and Basiony *et al.* (2017).

Carbohydrates content of labneh treatments increased significantly ($P\leq$ 0.05) by increasing the rate of supplementing labneh treatments with PPFP (Table 4). This increase might be due to the higher carbohydrates content of PPFP (86.93%) (Nieto-Calvache *et al*., 2018). At the same time, carbohydrates content of labneh treatments significantly (P≤0.05) decreased as storage period proceeded. This decrease may be due to the fermentation of some carbohydrates by microflora in labneh. These results are in accordance with those reported by Fathi *et al*. (2005).

The total phenolic compounds content and antioxidant activity of labneh treatments increased with increasing supplementation rate of PPFP as indicated in Table (4). These findings may be attributed to the higher total phenolic compounds content and antioxidant activity of PPFP as shown in

Table (1). Nieto-Calvache *et al.* (2016) found that PPFP contained many phenolic compounds such as protocatechuic acid hexoside, quercetin 3-*O*-rutinoside, manghaslin, ferulic acid and caffeoylhexoside. In addition, lactic acid bacteria (LAB) has been shown to release bioactive peptides with antioxidant properties in yogurt (Farvin *et al.,* 2010). However, the total phenolic compounds content and antioxidant activity of labneh treatment decreased significantly ($P \leq 0.05$) as storage period advanced. These results are in agreement with those reported by Atwaa *et al.* (2020), Pérez-Chabela *et al*. (2021) and Heba *et al.* (2022). The decline of total phenolic compounds content and antioxidant activity during storage period of labneh treatments might be due to the acceleration of oxidation and subsequently decline of antioxidant activity that used to remove the reactive oxygen species (Karaaslan *et*

Table 2: Effect of incorporating papaya pulp fibers powder on titratable acidity, pH value and total solids of functional labneh during storage.

Treatments	Storage period (days)					
	Fresh	**7**	**14**	**21**	**28**	**Means****
			Titratable acidity (%)			
C*	1.19	1.24	1.33	1.38	1.46	1.37F
T_1	1.22	1.28	1.39	1.46	1.52	1.37EF
T_2	1.24	1.30	1.43	1.48	1.54	1.37E
T_3	1.28	1.32	1.43	1.51	1.59	1.37D
T_4	1.28	1.36	1.45	1.51	1.62	1.37C
T_5	1.31	1.36	1.49	1.56	1.64	1.37B
T_6	1.33	1.38	1.51	1.58	1.66	1.37A
Means**	1.26^{e}	1.32^{d}	1.432^{c}	1.49^{b}	1.57^{a}	
			pH value			
C*	4.48	4.41	4.35	4.35	4.33	4.38^{A}
T_1	4.48	4.40	4.33	4.32	4.30	4.36^{A}
T_2	4.42	4.36	4.30	4.29	4.26	4.32^{B}
T_3	4.38	4.32	4.28	4.26	4.24	4.29^{BC}
T_4	4.34	4.32	4.30	4.26	4.24	4.29^{BC}
T_5	4.34	4.30	4.26	4.22	4.20	4.26^{CD}
T_6	4.32	4.28	4.22	4.19	4.17	4.32^{D}
Means**	4.39^{a}	4.34^{b}	4.29^{c}	4.26^{d}	4.24^{d}	
			Total solids (%)			
C*	23.18	23.51	23.72	23.91	24.09	23.68^{G}
T_1	23.77	23.96	24.15	24.32	24.56	24.15^{F}
T_2	24.43	24.87	25.09	25.26	25.41	25.01^{E}
T_3	24.98	25.21	25.72	25.91	26.18	25.60^{D}
T_4	25.66	25.78	26.01	26.28	26.43	26.03^{C}
T_5	26.32	26.62	26.92	27.13	27.30	26.85^{B}
T_6	27.01	27.26	27.43	27.66	27.82	27.436^{A}
Means**	25.05^{a}	25.31^{a}	25.57^{a}	25.78^{a}	25.97^{a}	

*C: Control labneh with 15% papaya juice. T1, T2, T3, T4, T5 and T6 labneh treatments made by adding 15% papaya juice and 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0% papaya's pulp fibers powder, respectively.

** means with different small superscripts in the same row means the treatments are different during storage period, while means with different capital superscripts in the same columns means the treatments are significantly at significant level 0.05%.

Table 3: Effect of incorporating papaya pulp fibers powder on protein, fat and ash of functional labneh during storage.

Treatments	Storage period (days)				
	Fresh	**7**	**14**	**21**	**28**	**Means****
			Protein (%)			
C*	9.97	10.09	10.16	10.21	10.28	10.14^{A}
T_1	9.95	10.13	10.20	10.26	10.32	10.17^{A}
T_2	9.98	10.18	10.26	10.32	10.39	10.22^{A}
T_3	9.96	10.20	20.29	10.36	10.42	12.24^{A}
T_4	10.01	10.16	10.23	10.31	10.38	10.21^{A}
T_5	9.98	10.17	10.25	10.33	10.40	10.22^{A}
T_6	10.03	10.17	10.31	10.39	10.46	10.27^{A}
Means**	9.98^{a}	10.15^{a}	11.67^{a}	10.31^{a}	10.37	
			Fat (%)			
C*	11.20	11.20	11.40	11.60	11.60	11.40^{A}
T_1	11.10	11.30	11.50	11.70	11.90	11.50^{A}
T_2	11.20	11.40	11.50	11.80	12.00	11.58^{A}
T_3	11.30	11.50	11.60	11.80	12.10	11.66^{A}
T_4	11.20	11.40	11.60	11.90	12.10	11.64^{A}
T_5	11.30	11.50	11.60	11.90	12.20	11.70^{A}
T_6	11.30	11.50	11.70	11.90	12.20	11.72^{A}
Means**	11.22^{a}	11.40^{a}	11.55^{a}	11.80^{a}	12.01^{a}	
			Ash (%)			
C*	1.18	1.22	1.28	1.36	1.43	1.29^{C}
T_1	1.18	1.24	1.30	1.38	1.43	1.30^{BC}
T_2	1.20	1.24	1.29	1.41	1.46	1.32^{AB}
T_3	1.20	1.26	1.32	1.40	1.49	1.33^{AB}
T_4	1.22	1.26	1.31	1.42	1.52	1.34^{AB}
T_5	1.23	1.27	1.33	1.42	1.50	1.35^{AB}
T_6	1.25	1.29	1.33	1.43	1.53	1.36^{A}
Means**	1.20^{c}	1.25^{bc}	1.30^{abc}	1.40^{ab}	1.48^{a}	

*C: Control labneh with 15% papaya juice. T1, T2, T3, T4, T5 and T6 labneh treatments made by adding 15% papaya juice and 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0% papaya's pulp fibers powder, respectively.

** means with different small superscripts in the same row means the treatments are different during storage period, while means with different capital superscripts in the same columns means the treatments are significantly at significant level 0.05%.

Table 4: Effect of incorporating papaya pulp fibers powder on carbohydrates, total phenolic compounds and antioxidant activity of functional labneh during storage.

Treatments	Storage period (days)					Means**
	Fresh	7	14	21	28	
Carbohydrate (%)						
C*	0.83	1	0.88	0.74	0.78	0.84^{G}
T_1	1.54	1.29	1.15	0.98	0.91	1.17^{F}
T_2	2.05	2.05	2.04	1.73	1.56	1.88^{E}
T_3	2.52	2.25	2.51	2.35	2.21	2.36^{D}
T_4	3.23	2.96	2.87	2.65	2.43	2.82^{C}
T_5	3.81	3.68	3.74	3.48	3.20	3.58^{B}
T_6	4.43	4.30	4.09	3.94	3.63	4.07^{A}
Means**	2.63a	2.50b	2.46c	2.26d	2.10e	
Total phenolic compounds (mg gallic acid/100g labneh)						
C*	4.13	3.98	3.01	2.87	2.56	3.31^{g}
T_1	7.72	6.15	5.74	4.02	3.68	5.46^{f}
T_2	11.65	8.71	7.39	5.96	4.85	7.71^{e}
T_3	17.32	13.46	11.06	9.11	7.19	11.62^{d}
T_4	21.84	18.91	15.18	12.36	10.88	15.83^{c}
T_5	23.58	21.02	19.06	15.41	13.25	18.46^{b}
T_6	26.09	22.94	19.85	16.85	14.58	20.06^{a}
Means**	16.04a	13.59b	11.61c	9.51d	8.14e	3.31^{G}
Antioxidant activity (%)						
C*	19.65	16.05	12.13	10.83	8.25	13.38^{G}
T_1	32.66	26.38	23.06	20.64	17.85	24.11^{F}
T_2	35.91	29.82	25.18	23.01	20.15	26.81^{E}
T_3	43.15	36.41	30.85	26.69	22.53	31.92^{D}
T_4	50.36	45.61	41.15	35.55	31.37	40.80^{C}
T_5	58.25	52.66	45.28	38.74	35.16	46.01^{B}
T_6	63.11	55.08	48.13	41.43	36.02	48.75^{A}
Means**	43.29^{a}	37.43^{b}	32.25^{c}	28.12^{d}	24.47^{e}	

*C: Control labneh with 15% papaya juice. T1, T2, T3, T4, T5 and T6 labneh treatments made by adding 15% papaya juice and 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0% papaya's pulp fibers powder, respectively.

** means with different small superscripts in the same row means the treatments are different during storage period, while means with different capital superscripts in the same columns means the treatments are significantly at significant level 0.05%.

al., 2011) and/or the interaction between the proteins and polyphenolic compounds (Heinonen *et al*., 1998). This interaction depends on both type and amounts of protein and bioactive compounds (Arts *et al*., 2002).

Microbiological properties

Total count of bacteria, Streptococci, Lactobacilli and Bifidobacteria counts of treatments increased significantly ($P \leq 0.05$) as the rate of supplementing labneh with PPFP increased (Table 5, 6) and Table (4). This increase may be due to the stimulation effect of PPFP that contains many constituents which may stimulate the growth of bacteria such as dietary fibers, fermentable carbohydrates, antioxidant compounds, vitamins and minerals those might act as prebiotics (Parra-Matadamas *et al.,* 2015) and/or may be due to microflora pre-

Table 5: Effect of incorporating papaya pulp fibers powder on microbiological properties of functional labneh during storage.

Treatments	Storage period (days)					Means**
	Fresh	7	14	21	28	
Total bacteria counts of (CFU × 10^7/gm)						
C*	86	98	105	93	79	92.2^{G}
T_1	88	102	113	97	82	96.4^{F}
T_2	103	116	122	109	91	108.2^{E}
T_3	115	123	136	117	102	118.6^{D}
T_4	119	126	135	123	110	122.6^{C}
T_5	127	138	143	125	119	130.4^{B}
T_6	133	148	142	131	120	134.8^{A}
Means**						
Lactobacilli counts (CFU × 10^7/gm)						
C*	71	83	91	76	55	75.2^{G}
T_1	75	91	103	81	58	81.6^{F}
T_2	86	98	118	85	56	88.6^{E}
T_3	88	101	122	91	62	92.8^{D}
T_4	88	105	127	90	65	95^{C}
T_5	91	113	133	102	74	102.6^{B}
T_6	95	122	135	109	82	108.6^{A}
Means**	84.85d	101.85d	118.42a	90.57c	64.57e	
Streptococci counts (CFU × 10^7/gm)						
C*	62	71	66	58	36	58.6^{G}
T_1	60	75	70	63	42	62^{F}
T_2	65	81	76	72	56	70^{E}
T_3	68	86	79	72	55	72^{D}
T_4	73	112	103	95	61	88.8^{C}
T_5	78	118	105	101	66	93.6^{B}
T_6	80	124	112	106	73	99^{A}
Means**	69.42^{d}	95.28^{a}	87.28^{b}	81^{c}	55.57^{e}	

*C: Control labneh with 15% papaya juice. T1, T2, T3, T4, T5 and T6 labneh treatments made by adding 15% papaya juice and 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0% papaya's pulp fibers powder, respectively.

** means with different small superscripts in the same row means the treatments are different during storage period, while means with different capital superscripts in the same columns means the treatments are significantly at significant level 0.05%.

Table 6: Effect of incorporating papaya pulp fibers powder on counts Bifidobacteria (CFU×10^7/gm) and mould and yeast (CFU×10^2/gm) of functional labneh during storagce.

Treatments	Storage period (days)					
	Fresh	7	14	21	28	Means**
			Bifidobacteria (CFU × 10^7/gm)			
C*	90	78	63	40	22	58.6^F
T_1	90	80	62	46	28	61.2^E
T_2	93	80	65	51	30	63.8^D
T_3	97	85	77	54	33	69.2^C
T_4	95	90	80	61	46	74.4^B
T_5	98	90	83	61	40	74.4^B
T_6	98	93	82	65	51	77.8^A
Means**	94.42a	85.14b	73.142c	54d	35.714e	
			Mould and yeast counts (CFU × 10^2/gm)			
C*	ND	ND	ND	26	33	
T_1	ND	ND	ND	15	29	
T_2	ND	ND	ND	ND	15	
T_3	ND	ND	ND	ND	ND	
T_4	ND	ND	ND	ND	ND	
T_5	ND	ND	ND	ND	ND	
T_6	ND	ND	ND	ND	ND	
Means**	ND	ND	ND	ND	ND	

*C: Control labneh with 15% papaya juice. T1, T2, T3, T4, T5 and T6 labneh treatments made by adding 15% papaya juice and 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0% papaya's pulp fibers powder, respectively.

** means with different small superscripts in the same row means the treatments are different during storage period, while means with different capital superscripts in the same columns means the treatments are significantly at significant level 0.05%.

sent in PPFP itself (Sule & Omologbe, 2017). On the other hand, there was gradual increase during the storage period reaching the maximum counts at 2 weeks of refrigerated storage period, then it decreased as storage period advanced which might be because of the impact of developed acidity and cold storage. that agree with results of Bakr *et al.* (2021), Zahid *et al.* (2022) and Heba *et al.* (2022). Meanwhile, total count of bacteria, and Lactobacilli counts increased to the fourteenth day of the storage period, while Streptococci counts of labneh treatments increased up to the first week of storage, then all their counts declined as storage period developed. In contrast, Bifidobacteria counts of all treatments significantly ($P \leq 0.05$) decreased throughout storage period. This decrease may be due to of the impact of developed acidity which is observed in (Table 2). These trends are similar to those of Mabrouk & Effat (2020), Bakr *et al.* (2021), and Zahid *et al.* (2022).

The effect of supplementing labneh with PPFP and the storage period on counts of mould and yeast are presented in Table (6). It could be noticed that mould and yeasts were detected at the end of storage period in the control labneh and T1 treatment, which can be due to the high hygienic conditions followed during the process of manufacturing labneh (Nasser *et al.,* 2017 & Mpopo *et al.,* 2020). Meanwhile, mould and yeasts could not be detected in all treatments supplemented with PPFP, which might be due to the presence of papain enzyme that inhibits the growth of mould and yeasts (Giordani *et al*., 1991, Giordani *et al*., 1997).

Organoleptic properties

Scores of organoleptic properties during the storage of labneh treatments are shown in Table (7). These results reveal that supplementation of labneh with PPFP up to 1.5% did not have a significant ($P \leq 0.05$) effect on the scores of organoleptic

Table (7). Effect of incorporating papaya pulp fibers powder on organoleptic properties of functional labneh during storage.

Treatments	Flavour (60)					Body and Texture (30)					Appearance (10)					Total Scores (100)				
	Storage period (days)																			
	Fresh	7	14	21	28	Fresh	7	14	21	28	Fresh	7	14	21	28	Fresh	7	14	21	28
C*	56^{Aa}	56^{Aab}	52^{Abc}	52^{Ac}	50^{Ad}	27^{Aa}	26^{Aa}	25^{Aa}	23^{Ab}	23^{Ac}	9^{Aa}	9^{Aa}	9^{Ab}	8^{Ab}	8^{Ac}	92^{Aa}	91^{Aab}	88^{Abc}	83^{Ac}	81^{Ad}
T_1	56^{Aa}	55^{Aab}	52^{Abc}	50^{AAc}	50^{Ad}	27^{Aa}	26^{Aa}	25^{Aa}	24^{Ab}	23^{Ac}	9^{Aa}	9^{Aa}	8^{Ab}	8^{Ab}	8^{Ac}	92^{Aa}	90^{Aab}	85^{Abc}	82^{Ac}	81^{Ad}
T_2	54^{Aa}	54^{Aab}	53^{Abc}	51^{AAc}	50^{Ad}	27^{ABa}	27^{Aba}	26^{ABa}	26^{ABb}	24^{ABc}	9^{Aa}	9^{Aa}	9^{Ab}	8^{Ab}	8^{Ac}	90^{Aa}	90^{Aab}	88^{Abc}	86^{Ac}	82^{Ad}
T_3	53^{ABa}	54^{ABab}	52^{ABbc}	49^{ABAc}	49^{ABd}	26^{ABa}	25^{Aba}	25^{ABa}	23^{ABb}	21^{ABc}	9^{Aa}	8^{Aa}	8^{Ab}	8^{Ab}	8^{Ac}	88^{ABa}	87^{ABab}	84^{ABbc}	80^{ABc}	78^{ABd}
T_4	50^{Ba}	50^{Bab}	48^{Bbc}	46^{BAc}	45^{Bd}	23^{BCa}	23^{BCa}	22^{BCa}	22^{BCb}	21^{BCc}	8^{Ba}	8^{Ba}	7^{Bb}	7^{Bb}	6^{Bc}	81^{Ba}	81^{Bab}	77^{Bbc}	73^{Bc}	72^{Bd}
T_5	45^{Ca}	43^{Cab}	43^{Cbc}	41^{CAc}	40^{Cd}	23^{CDa}	22^{CDa}	21^{CDa}	21^{CDb}	20^{CDc}	7^{Ca}	7^{Ca}	6^{Cb}	6^{Cb}	5^{Cc}	75^{Ca}	72^{Cab}	70^{Cbc}	68^{Cc}	65^{Cd}
T_6	41^{Da}	40^{Dab}	38^{Dbc}	35^{DAc}	33^{Dd}	22^{Da}	21^{Da}	20^{Da}	22^{Db}	21^{Dc}	7^{Ca}	7^{Ca}	6^{Cb}	6^{Cb}	5^{Cc}	70^{Da}	68^{Dab}	64^{Dbc}	61^{Dc}	59^{Dd}

*C: Control labneh with 15% papaya juice. T1, T2, T3, T4, T5 and T6 labneh treatments made by adding 15% papaya juice and 0.5, 1.0, 1.5, 2.0, 2.5 and 3.0% papaya's pulp fibers powder, respectively.

** means with different small superscripts in the same row means the treatments are different during storage period, while means with different capital superscripts in the same columns means the treatments are significantly at significant level 0.05%.

properties and the total scores, while the scores of organoleptic properties decreased by increasing the rate of supplementation above 1.5%. This decrease might be due mainly to the appearance of the bitter taste of labneh treatments. Scores of organoleptic properties of labneh treatments C, T1, T2 and T3 those made by adding 0.0, 0.5, 1.0 and 1.5% PPFP, respectively were not significantly ($P\leq$ 0.05) different from each other. Therefore, treatment T3 will be chosen as a best treatments because it contains higher counts of Bifidobacteria than those of labneh treatments (C, T1 and T2) which is very important for a good quality probiotic labneh. The organoleptic properties scores of labneh treatments have no significant change ($P\leq$0.05) during the 1st week of storage period, after that it decreased to the end of cooled storage (Othman *et al*., 2019, Atwaa *et al*., 2020, Heba *et al*., 2022)

CONCLUSION

This study concluded that, the use of papaya's pulp fibers powder and probiotics for producing functional labneh by adding papaya's pulp fibers powder up to 1.5% and 15% papaya's juice and Bifidobacteria without adversely affecting the quality of the labneh. Therefore, this labneh is suitable for patients with hypertension, diabetes, and heart disease.

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إنتاج لبنة داعمة للحيوية باستخدام مسحوق ألياف لب الباباظ وبكتيريا البروبيوتيك

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تناول هذا البحث تدعيم اللبنة ببكتيريا البروبيوتيك ومسحوق ألياف لب الباباظ (PPFP) كمواد حيوية، وكمصدر للألياف الغذائية والمركبات النشطة بيولوجيًا لتعزيز وظائفها الغذائية والعلاجية، لقد تم تصنيع اللبنة باستخدام مسحوق ألياف لب الباباظ بنسب صفر ١، ٥,١، ٢، ٥,٢، ٣٪ مع ١٥٪ من عصير الباباظ. وتم الخزين في الثلاجة لمدة ٢٨ يومًا وتم التحليل الكيميائي والميكروبيولوجى والحسي على فترات (صفر و٧ و ١٤ و ٢١ و ٢٨ يوماً). أظهرت النتائج المتحصل عليها أن إضافة مسحوق ألياف لب الباباظ أدي إلى زيادة الحموضة و المواد الصلبة الكلية و الرماد في حين لم يكن له تأثير معنوى على نسب البروتين والدهون على عكس محتوى الكربوهيدرات فقد زاد معنوياً. ومع تقدم فترة التخزين لم يكن لتدعيم اللبنة بمسحوق ألياف الباباظ أي تأثير على نسب المواد الصلبة الكلية. بينما انخفض رقم الأس الهيدروجيني (pH) وزاد محتوى المركبات الفينوليه و مضادات الأكسدة بزيادة التركيز. كما زاد العدد الكلي للبكتيريا وأعداد بكتيريا Lacto-bacilli لمعاملات اللبنة حتى اليوم الرابع عشر من فترة التخزين ، بينما زادت أعداد بكتيريا Streptococci لمعاملات اللبنة حتى اليوم السابع من التجربة ، ثم انخفضت الأعداد بعد ذلك خلال فترة التخزين. في حين انخفضت أعدد الـ Bifidobacteria لجميع معاملات اللبنة بشكل ملحوظ خلال فترة التخزين. من ناحية أخرى فلم يؤثر إضافة PPFP حتى نسبة ١,٥ ٪ على الخواص الحسية للبنة، أما زيادة معدل الإضافة عن ١,٥ ٪ فق أدى إلى انخفاض ملحوظ في الصفات الحسية.