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The effect of fortifying bio UF-labneh with germinated fenugreek seed flour on the physicochemical, microbial, rheological, and sensory properties

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Abstract

The effect of adding germinated fenugreek seed flour (GFS) (*Trigonella foenum-graecum*) on the physicochemical, microbiological, rheological, and sensory properties of bio UF-labneh cheese was studied. GFS was added at 0.5% (T_1), 1%, (T_2), and 1.5% (T_3). to UF-retentate used in making labneh cheese. The addition of GFS resulted in a significant effect on fibers, protein, ash, moisture, pH, total antioxidant activity (TAA), Total phenolic content (TPC), starter culture, vitamins, minerals, and water Holding Capacity (WHC) contents of labneh cheese. by increasing its concentration. Molds and yeasts did not appear in all treatments by added GFS up to 31 days of cold storage, however, they appear in control after 21 days. Results also showed a decrease in the numbers of TCB numbers with an increase of adding GFS, compared with the control. Gradual increases in TPA properties was observed with the increase of GFS, while an opposite trend was detected in the acidity, tyrosine, tryptophan, Total volatile fatty acids (TVFA), and Peroxide value. For all of the above, it is recommended to add GFS, especially in proportions of 0.5 or 1% to the bio-Uf-Labneh cheese, as it showed high sensory properties similar to control cheese and superior to it during the storage period. The product was functional, hygienic, and has a high quality.

Keywords: UF- Labneh, fenugreek seeds, Fenugreek germinated, prebiotic.

1. Introduction

Functional food that offer health benefits beyond basic nutrition and/or reduce the risk of chronic diseases—are currently receiving a lot of attention. Hence, after a portion of the whey is removed from yoghurt, labneh—an ancient fermented milk product popular in Middle Eastern nations—is produced. Similar to a cream-like consistency, the labneh is smooth, silky, and dispersible due to the presence of an acidic flavor and a milky white tint. Lactic acid bacteria strains digest the lactose present to produce organic acids, primarily lactic acid, which is then used to make labneh [38]. Therefore, labneh contains nutritional and health value as well as all the nutritional components that yoghurt enjoys, but in higher proportions than concentrated yoghurt. Even though many milk and its products' health and nutritional benefits are well-established [3]. To satisfy the needs of health-conscious consumers, new dairy product formulations incorporating medicinal plants or their extracts have a great attention [26]. Several novel fermented dairy products supplemented with plant-derived meals (fruit, vegetables, or even their by-products) have been developed and evaluated in this context [23].

The rich fiber, gum, and other phytochemical components of fenugreek are well known. Additionally, it has a lot of vitamins, minerals, and antioxidants. Other fenugreek ingredients include free amino acids, fixed oils (lipids), volatile oils, calcium, iron, and carbohydrates, particularly mucilaginous fiber (galactomannans) [1]. The main therapeutic characteristics of fenugreek, which have been proven

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in various research, are anti-diabetic, antioxidant, anti-carcinogenic, hypoglycemic, and hypocholesterolemic effects. Fenugreek can be suggested as a component of our regular diet and added to meals to create functional food based on these numerous health benefits [12].

The physical process of seed germination has frequently been used in the past to increase the nutritional value and safety of edible seeds [29], [15]. It has been proven that the nutritional content and fiber content of fenugreek seeds improve during germination, facilitating the process of digestion and absorption by the body. The germination technique also awakens dormant seed enzymes and launches a variety of enzymatic reactions that break down stored proteins, carbohydrates, and lipids into simpler components [10]. In addition, germinated fenugreek seeds contain more antioxidants and have a stronger anti-diabetic effect than their boiled counterparts. During this process, it also significantly accelerates the breakdown of carbohydrates, amino acids, and organic acids [19]. It was found that the use of any part of the fenugreek plant in food is anti-microbial and anti-cancer. Parasites and fungi also cause hypocholesterolemia because they contain active biological compounds [51].

Due to customer requests to replace food preservatives with natural elements that have a noticeable effect, attention to the use of food preservation is continuously growing Van et al. [50], [52].

For all of the above, the study aimed to produce a healthy functional brick with a high nutritional and vital value as a result of fortifying it with dried germinated fenugreek seeds. Also, the physicochemical, rheological, microbial, and sensory properties of the brick and its content of vitamins, minerals, and antioxidants were estimated while improving its shelf life.

2. Experimental

2.1. Materials

The dairy industry units of the Animal Production Research Institute, Ministry of Agriculture, Giza, Egypt, provided the UF-retentate that was used in the production of UF labneh. Fenugreek seeds were purchased from the local market in Giza, Egypt. All chemicals, substances, microbiological media and used in the current research were of analytical grade and obtained from Oxiod, Egypt. Lactic acid strains used in manufacturing UF labneh as (*Lactobacillus bulgaricus* Lb-12 DRI-VAC, *L. acidophilus* CH-2, and *Streptococcus thermophilus* CH-1) were obtained from Chr.Hansen's Lab., Denmark.

2.2. Preparation of bio UF-Labneh

UF-labneh was made according to El-Sayed, et al. **[16]** , El-Sayed, et al. $_b$ **[17]**. UF-retentate was pasteurized at 72˚C / 5 min and rapidly cooled to 42˚ C. Lactic acid strains *Lb. acidophilus* 1%, *S. thermophilus* 1%, and *Lb. bulgaricus* 1% were inoculated into pasteurized UF-retentate. The inoculated UF-retentate was distributed into 4 portions; the first part was severed as (C) control, and the other 3 portions were fortified with 0.5, 1.0, and 1.5% of GFS treatments (GFS_1, GFS_2, and GFS_3). All these treatments are packed in polystyrene cups (70 ml). The cups were incubated at 42˚ C till coagulation and, after that, cold-stored (5± 1˚C) for 31 days.

2.3. germinated Fenugreek seeds flour preparation

Fenugreek seeds (50 g) were soaked in water at a ratio of 1:5 (w/v) for the duration of the night. Seeds were kept in the dark for germination (tied in a muslin cloth) at a temperature of 27°C ± 2°C for 24 hours after the surplus water had been drained. The germination seeds were dried in a 40± 2°C oven for 6 hours. and then ground to a fine powder. Hemlata and Pratima, **[22]**

2.4. Physicochemical analysis

Moisture, total protein (TP) fat, ash, fiber contents, acidity (TA%), and pH values (using pH meter, Jeneway) were determined in both raw materials and UF- labneh cheese samples according to the method described by AOAC **[5]**. The Carbohydrates % was determent as a difference between protein; fat; fiber; ash, salt, and moisture % content of carbohydrates calculated by the differences. Ascorbic acid, B- carotene, vitamins B_1, B_2, and the mineral contents were determined according to the method described by the AOAC **[5]** using an atomic absorption spectrometer. Total phenolic compounds were determined by the Folin-Ciocalteau method Ebrahimzadeh, *et al.* **[13].** The antioxidant activity of JPR methanolic extract was evaluated by the stable 2,2-diphenyl-1-picryl-hydrazyl (DPPH, Sigma Aldrich, Germany) radical scavenging method as described by Matthäus,**[33]**. The method described was used to determine the total amount of volatile fatty acids Kowsikowski, **[30].** Peroxide value was described by AOAC **[5]**, and IUPAC **[24]**. Tyrosine and tryptophan (mg/100) contents were determined according to Vakaleris and Price **[49]**.

2.5. Water Holding Capacity(WHC)and Syneresis of bio U-F Labneh cheese

Water Holding Capacity(WHC) and Syneresis were culcolated by Omojola, et al. **[37].**

The Water-holding capacity of UF- labneh cheese is calculated by the following formula:

WHC% = Y - W / Y x 100

Y: 20 g from a sample after cooling to 4±1 ° C in one day of storage were centrifuged for 10 min., at 3000 rpm at 20°C.

W: The released serum was removed and weighed.

Syneresis was measured after samples (about 20 g) were cooled to +4°C in 24 hours of storage (Y). Samples were centrifuged for 5 min., 500 rpm at 20°C. The released serum (S) was removed and weighed. Syneresis of bio UF- labneh cheese is calculated by the formula:

Syn = S / Y X 100.

All results are in grams of water/100 g of the bio UF- Labneh.

2.6. Microbiological Analysis of bio UF- Labneh cheese

L. acidophilus count was determined according to Dave and Shah **[9]** using MRS-Salcin agar. The plates were incubated at 37˚C / 48 hrs. The conventional plate count method was used to determine the viable counts of *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus* in yoghurt samples at various sampling points, as per Ogunsina, et al. **[35]**. *S. thermophilus* and *L. bulgaricus* were counted using M17 and MRS agar culture mediums, respectively. For the enumeration of *S. thermophilus* and *L. bulgaricus*, the plates were incubated in anaerobic conditions at 42°C for 48 hours or 37°C /72 hours, respectively. Total count was performed using nutrient agar (Oxoid, UK) at 40 – 42°C for 48h. Mold and yeast were determined according to Ryu and Wolf-Hall **[40].** Colony-forming units (CFU) per gram (log cfu/g) were used to express the results.

2.7. Texture profile analysis (TPA):

Using a Universal Testing Machine (TMS-Pro) outfitted with a 1000 N (250 lbf) load cell and connected to a computer running Texture ProTM texture analysis software, texture profile analysis tests were conducted on samples of Kareish cheese (program, DEV TPA withhold). The texture profile parameters were obtained using a calculation as given by Bourne **[8]**.

2.8. Sensory Evaluation of bio UF- Labneh cheese

Sensory evaluation of UF labneh during cold storage for eight weeks was displayed. 50 g of labneh samples were evaluated as recommended by the method of Obi *et al.*, **[34]** for color & appearance, body & texture, odor, taste, and overall acceptability, by 10 panelists who had previous knowledge of the sensory quality of dairy products from the staff of the [dairy chemistry research department, Animal Production Research Institute, and dairy research department, Food Technology Research Institute Agriculture Research Centre (ARC), Egypt.

2.9. Statistical Analysis

It was performed using the SPSS version (10) computer program **[47]** Inc. Chicago IL USA. Results were subjected to ANOVA and Duncan's Test to determine significant differences among means at the significance level of 0.05. Data were expressed as the mean ±SE of three replicates.

3. Results and Discussion

3.1. Chemical composition of Fenugreek seeds flour (FS) and germinated Fenugreek seeds (GFS) flour.

Table 1 showed the differences between dried fenugreek seeds (FS) and cultivar dried fenugreek seeds (GFS) in several analyses and estimates. It was observed that GFS increased in its content of protein, ash, fiber, moisture, and acidity over FS. While the c content of fat, carbohydrates, and pH decreased. Concerning minerals, vitamins, and antioxidants, it was found that GFS is higher than FS in its content of Ca, P, Cu, Zn, K, Na, and Mg. as well as in vitamins such as C, B1, and B2. Also, GFS is higher than FS in total phenolic compounds and total antioxidants. The results are similar to what found in [25]; [39]; [44]; [45]; [48]; [53].

Table (1): The chemical composition of Fenugreek seeds flour (FS) and germinated Fenugreek seeds (GFS) flour.

Character assessed		Fenugreek seeds flour (FS)	germinated Fenugreek seeds flour (GFS)
Moisture	%	6.42[a]	5.16[b]
Protein	%	27.04[b]	32.36[a]
Ash	%	3.68[b]	4.74[a]
Fat	%	4.84[a]	3.68[b]
Curd fiber	%	7.06[b]	10.32[a]
Available Carbohydrates	%	50.96[a]	43.74[b]
*TitratableAcidity	%	0.48[a]	1.22[a]
pH- value		6.33[a]	5.33[b]

Ca	(mg/100g)	1661.20^{b}	2002.77^{a}
P	(mg/100g)	261.42^{b}	447.34^{a}
Cu	(mg/100g)	1.88^{b}	2.35^{a}
Mg	(mg/100g)	220.14^{b}	257.38^{a}
Zn	(mg/100g)	3.98^{b}	5.46^{a}
Fe	(mg/100g)	12.04^{a}	11.74^{b}
K	(mg/100g)	535.01^{b}	550.27^{a}
Na	(mg/100g)	115.02^{b}	136.22^{a}
Vitamin C	(mg/100g)	5.28^{b}	18.36^{a}
Thiamin (B_1)	(µg/100g)	341^{b}	452^{a}
Riboflavin(B_2)	(mg/100g)	292^{b}	348^{a}
B- carotene	(mg/100g)	96^{a}	92^{b}
Total phenolic	%	45.12^{b}	80.78^{a}
DPPH	%	$18.64^{\ b}$	74.22^{a}

*Determined in 20% aqueous solution (w/v).

As shown in Table 2, fortification of bio UF-labneh cheese of GFS resulted in significant ($P \leq 0.05$) differences in moisture, protein, ash, fiber, and carbohydrate content. Control treatment (C) had the lowest moisture content (73.48 ± 0.02, 72.67 ± 0.02), both in the fresh treatment and after 31 days of storage, while the GFS3 treatment had the highest humidity levels (75.33 ± 0.002 and 73.45 ±0.006, respectively). The addition of GFS increased the formation of protein, fats, fibers, and ash content of bio UF-labneh cheese-enriched adobe of GFS ($P \leq 0.05$). On the other hand, there was a significant decrease ($P \leq 0.05$) in the carbohydrate content with an increase in GFS in bio UF-labneh cheese. Moreover, there were notable differences in how the storage period affected the chemical composition of the bio UF-labneh cheese. These results were similar to [16]; [44]; [20].

Table 2. Chemical composition of bio UF-Labneh cheese fortified with different levels of GFS during the storage period.

Cold storage period (days)	C	GFS_1	GFS_2	GFS_3
		Moisture %		
1	^{Ad} ± 0.02 73.48	74.62 ± 0.02^{Ab}	74.09 ±0.002^{Ac}	75.33 ±0.002^{Aa}
11	$^{B\ c}$ 73.16 ± 0.02	73.72 ±0.02^{Bb}	73.72 ± 0.02^{ABb}	74.88 ± 0.2^{Ba}
21	^{Cc} 72.90 ± 0.02	73.350 ± 0.02^{Cab}	73.35 ± 0.07^{BCb}	74.22 ±0.4^{Ca}
31	72.67 ± 0.02 ^{Cc}	73.06 ± 0.01^{Db}	73.06 ± 0.01^{Cb}	73.45 ±0.006^{Da}
		Protein%		
1	9.34 ± 0.02^{Bc}	9.51 ± 0.02^{Ac}	9.66 ± 0.11^{Ab}	10.02 ± 0.01^{Aa}
11	9.40 ± 0.11^{ABa}	9.61 ± 0.05^{Aa}	9.75 ± 0.11^{Aa}	10.14 ± 0.02^{Aa}
21	9.49 ±0.02^{ABd}	9.68 ± 0.005^{Ac}	9.86 ± 0.005^{Ab}	10.30 ± 0.02^{Aa}
31	9.57 ± 0.11^{Ad}	9.73 ±0.01^{Ac}	10.01 ± 0.005^{Ab}	10.42 ± 0.01^{Aa}
		Fat %		
1	4.80 ± 0.05^{Ba}	4.85 ± 0.005^{Aa}	4.90 ± 0.11^{Aa}	5.00 ± 0.11^{Aa}
11	4.85 ± 0.005^{ABa}	4.90 ± 0.11^{Aa}	5.00 ± 0.17^{Aa}	5.05 ± 0.02^{Aa}
21	4.90 ± 0.08^{ABa}	4.96 ±0.01^{Aa}	5.05 ± 0.01^{Aa}	5.10 ± 0.15^{Aa}
31	5.0 ± 0.03^{Aa}	5.05 ± 0.01^{Aa}	5.10 ± 0.06^{Aa}	5.20 ± 0.11^{Aa}
		Ash%		
1	0.9120± 0.01^{Dd}	0.9358±0.001^{Dc}	0.9593±0.001^{Db}	0. 9833±0.001^{Da}

11	1.0321± 0.01^{Cc}	1.0518±0.005^{Cbc}	1.0947±0.005^{Cab}	1.0968± 0.01^{Ca}
21	1.1412± 0.01^{Bb}	1.1801±0.005^{Ba}	1.1991±0.005^{Ba}	1.2020±.005^{Ba}
31	1.2523 ± 0.005^{Ac}	1.2964±0.01^{Ab}	1.3028±0.01^{Ab}	1.3862±0.01^{Aa}
		Fiber %		
1	ND	0.052± 0.005^{Bb}	0.133±0.005^{Da}	0.155±0.^{01Ca}
11	ND	0.076± 0.01^{Bc}	0.157±0.006^{Cb}	0.177±0.01^{BCa}
21	ND	0.110± 0.008^{Ab}	0.178±0.006^{Ba}	0.195±0.004^{ABa}
31	ND	0.129± 0.006^{Ac}	0.196±0.002^{Ab}	0.218±0.006^{Aa}
		Carbs %		
1	11.47±0.01^{Ca}	10.56±0.01^{Cb}	10.27±0.02^{Bc}	8.52±0.02^{Dd}
11	11.55±0.01^{Aa}	10.64±0.02^{Bb}	10.26±0.03^{Bc}	8.66±0.02^{Cd}
21	11.57±0.01^{Aa}	10.72±0.02^{Ab}	10.38±0.01^{Ac}	8.99±0.01^{Bd}
31	11.51±0.01^{Ba}	10.75±0.01^{Ab}	10.34±0.02^{ABc}	9.34±0.02^{Ad}

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level. The means with the same letter at any position were not significantly different (P > 0.05) ND: Not detected

The data shown in Table (3) showed that the treatment of GFS_3 and GFS2 reduced clotting time to 90 minutes, while the treatment of GFS1 increased to 120 minutes to complete coagulation, while the control treatment occurred at 150 minutes. The reduction in the incubation time of treatments fortified with GFS compared to the control treatment is attributed to the interaction of fenugreek protein with milk components and determines its ability to stabilize and emulsify bio UF-labneh cheese. Thus, the acceleration of coagulation, as well as the containment of fenugreek seeds on gum was observed. So it acts as an emulsifier and stabilizer, and this can be explained by the short time of curdling in the transactions by increasing the percentage of adding GFS. This is confirmed by Wani and Kumar [51]; Khan,et al,.[28]. On the other side, a higher dietary fiber level found in fenugreek serves as a prebiotic in functional foods Lee, [31]. According to Sowmya and Rajyalakshmi [46], fenugreek's soluble fiber serves as a fantastic substrate for fermentation carried out by the bacteria in the large intestine.

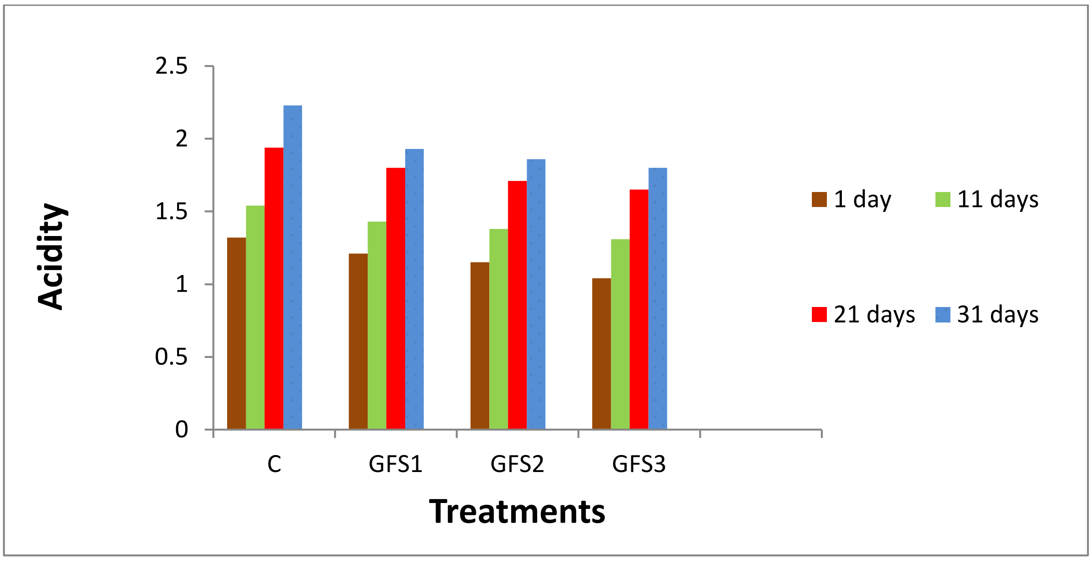
Table 3. Acidity development of bio UF-Labneh cheeses fortified with different levels of GFS during Incubation time after (min).

Incubation time/ min	Treatments			
	C	GFS_1	GFS_2	GFS_3
0.0	0.25 ± 0.005^{Ac}	0.27 ± 0.01^{Dc}	0.35 ±0.01^{Cb}	0.42 ± 0.01^{Ca}
30	0.34 ± 0.01^{Ad}	0.50 ± 0.01^{Cc}	0.62 ±0.01^{Bb}	0.71 ± 0.005^{Ba}
60	0.42 ± 0.005^{Ac}	0.75 ± 0.02^{Bb}	0.9267±0.03^{Aa}	0.97 ± 0.005^{Aa}
90	0.64 ± 0.02^{Ab}	0.94 ± 0.01^{Aa}	coagulated	coagulated
120	0.6533± 0.03^{A}	Coagulated	coagulated	coagulated
150	coagulated	Coagulated	coagulated	coagulated

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level. The means with the same letter at any position were not significantly different (P > 0.05) ND: Not detected

3.2. PH value and Acidity % of bio UF- Labneh cheese

Figure 1 depicted the variations in acidity and pH of UF-labneh cheese Fortified with GFS; the treatments had a significant impact on these variables (P≤ 0.05). The obtained results showed that control treatment (C) gained the highest acidity values at both the first day and 31 days of storage, achieving 1.32 and 2.23%, respectively. At GFS3, the lowest acidity percentage was gained on the first day and after 31 days of storage, gaining 1.04 % on the first day time and gradually increasing to reach 1.8 % after 31 days of storage. It was also noted that acidity decreases with the increase in the addition of GFS. On the other hand, the pH of PRS_3 dropped from 6.36 at the first day to 4.84 after 31 days of storage. While the C treatment's pH is lower on the first day and the long storage period. These results were in agreement with **[51]**, **[54]**.



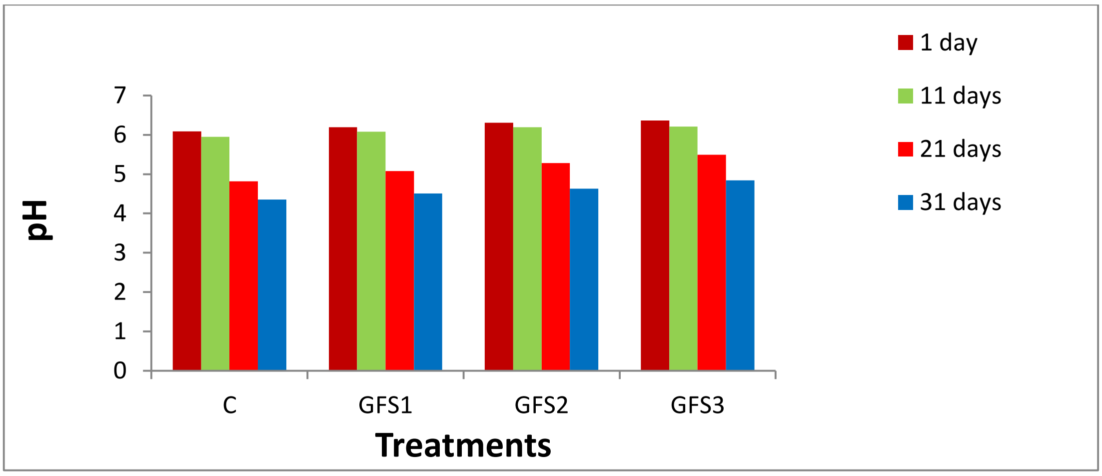


Figure 1. Acidity and pH of bio UF- Labneh cheese fortified with different levels of GFS during storage at 5±1°C
C, Control bio UF- Labneh cheese; GFS1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour)

3.3. Minerals and Vitamins of bio UF- Labneh cheese

Regarding the minerals and vitamin contents of bio UF- labneh cheese, data were given in Table 4 which indicated that the GFS caused a significant (P ≤ 0.05) increase in the Ca, Na, P, Cu, Mg, Zn, and K contents. Also, the addition of GFS led to an increase in vitamins content (C, B_1, B_2, and B- carotene). In Table 9, the increase in minerals and vitamins in the treatments fortified with GFS is attributed to the percentage of minerals and vitamins present in the germinated fenugreek seed and the percentage added from it to the retentate milk for the manufacture of UF-labneh (Table 1.). These results agreed with **[11]; [39]; [44]; [45].**

Table (4): Minerals and Vitamins of bio UF- Labneh cheese fortified with different levels of GFS at 5±1°C.(Average of three replicates).

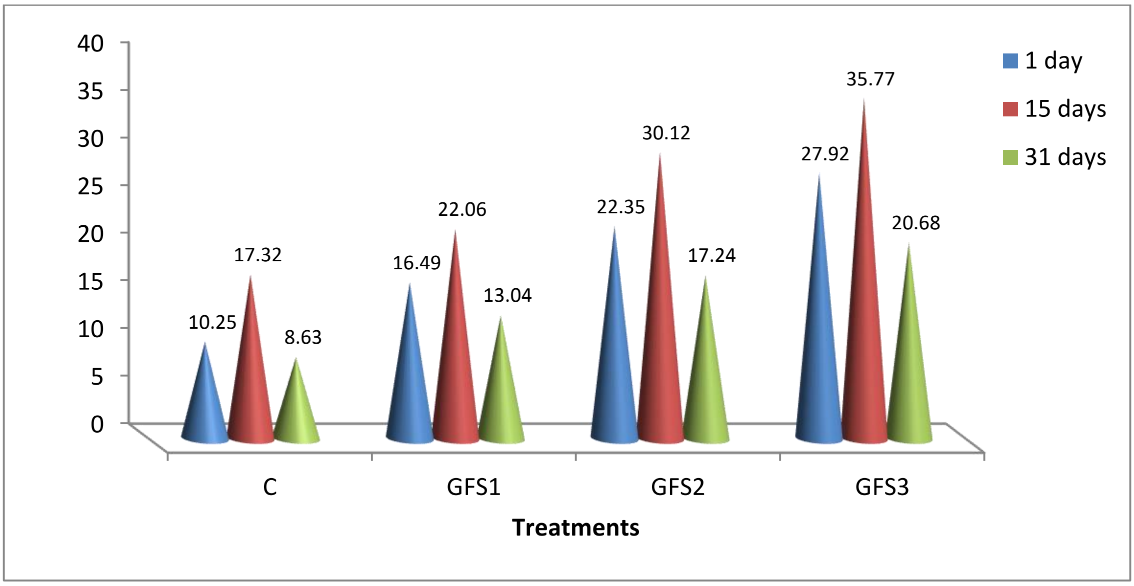
Properties	Treatments			
	C	GFS_1	GFS_2	GFS_3
		Minerals (mg/100g cheese)		
Ca	243.66^{d}	253.78^{c}	264.08^{b}	274.25^{a}
P	225.44^{d}	227.68^{c}	229.93^{b}	232.14^{a}
Cu	0.097^{d}	0.109^{c}	0.120^{b}	0.132^{a}
Mg	19.93^{d}	21.22^{c}	22.54^{b}	23.81^{a}
Zn	0.06^{d}	0.087^{c}	0.113^{b}	0.139^{a}
Fe	0.69^{d}	0.749^{c}	0.810^{b}	1.045^{a}
K	87.85^{d}	90.61^{c}	94.34^{b}	96.12^{a}
Na	78.0^{d}	78.682^{c}	79.364^{b}	80.043^{a}
		Vitamins (mg/100g cheese)		
Vitamin C	2.10^{c}	2.192^{b}	2.284^{ab}	2.375^{a}
Thiamin (B_1) (µg/100g)	$0. 86^{d}$	2.346^{c}	4.607^{b}	6.867^{a}
Riboflavin(B_2)	0.179^{d}	1.919^{c}	3.659^{b}	5.402^{a}
B- carotene	ND	0.462^{c}	0.923^{b}	1.387^{a}

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level.

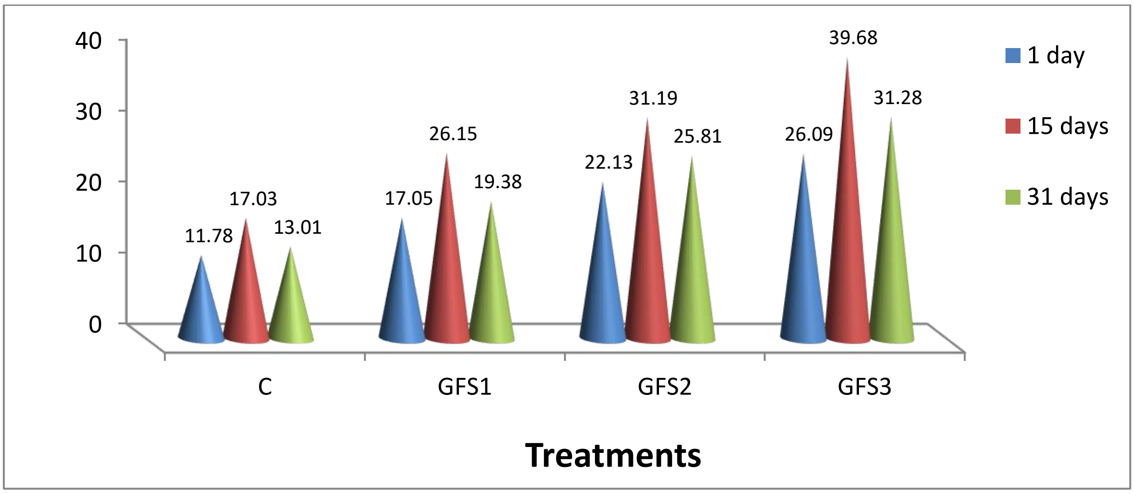
The means with the same letter at any position were not significantly different (P > 0.05) ND: Not detected

3.4. Total phenolic content (equivalent mg Gallic acid/100gm) and antioxidant activity (%) of bio UF-Labneh cheese

As indicated in figure 2 for the total phenolic components (TPC) and total antioxidants activity (TAA) found in fortified with GFS labneh cheese. It was noted in figure 2 that there were significant differences (P ≤ 0.05) between the treatments in the TPC, where GFS_3 was the highest in the TPC, on the contrary, the C treatment was the lowest. In Figure 2, it was shown that the TPC along the storage period was significantly different (P≤ 0.05). They increased up to 15 days and then decreased to 31 days. It was in GFS_3 after one day of storage, 26.09, then after 15 days it was 35.77, and at the end of storage, it was 31.28.



Total phenolic content



Antioxidant activity (%)

Figure 2. Total phenolic content (equivalent mg Gallic acid/100gm) and antioxidant activity (%) of bio UF- Labneh cheese fortified with different levels of GFS during storage at 5±1°C. (Average of three replicates).

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour)

It was noted in Figure 2 that the process of germinating fenugreek seeds increased the phenolic compounds and antioxidants in the fortified labneh cheese, and this was confirmed by **[11]; [15]; [28].** One of the many metabolic changes that the sprouting of seeds is known to generate in seeds is an increase in antioxidant activity. This alteration can have resulted from the combination of different chemicals**.** Jain, *et al.*, **[25].**

3.5. Evaluation of Total bacterial count ,molds, and yeast of bio UF-Labneh cheese

Table 5 illustrates the total bacterial count as affected by adding the GFS powder to bio UF-labneh cheese. It could be see that the total bacterial count of the control treatment increased clearly as compared with other treatments by progressing the storage period. The results may be due to the GFS effect during the storage period. Also, it could be observed that the total bacterial count decreased with increasing the GFS level during the storage period. GFS_3 had the lowest total bacterial count at the end of the storage period. During the period of storage, these findings revealed that the most inhibitory effects were observed when GFS was added in the highest quantity. These results were confirmed by **[11]**, **[54].**

Table 5 showed molds and yeasts began to appear after 21 days in the control treatment; however, they were not detected in the treatments fortified with GFS during a prolonged storage period. Perhaps delaying the appearance of yeasts and fungi might be due to the addition of GFS binds the water in the bio UF-labneh chees because GFS contains an emulsifier and stabilizer Wani and Kumer, **[51]** which reduces the chance of its growth.

Table (5): Microbiological counts (log CFU/ mL) of bio UF-Labneh cheeses fortified with different levels of GFS during storage at 5±1°C.

Cold storage period (days)	Treatments			
	C	GFS_1	GFS_2	GFS_3
	Total bacterial counts (log CFU /g)			
1	7.63 ± 0.01^{Da}	7.37 ± 0.01^{Db}	7.25 ± 0.01^{Dc}	6.74 ± 0.005^{Cd}
11	8.65 ± 0.005^{Bb}	7.73 ± 0.01^{Ca}	7.68 ± 0.01^{Cc}	7.44 ± 0.02^{Bd}
21	9.11 ± 0.005^{Aa}	8.57 ± 0.01^{Aa}	8.30 ± 0.02^{Aa}	8.05 ± 0.02^{Ac}
31	8.14 ± 0.01^{Cb}	8.18 ± 0.01^{Ba}	8. 10± 0.05^{Ba}	8.00 ± 0.01^{Ab}

	Mold &Yeast counts (log CFU /g)			
1	ND	ND	ND	ND
11	ND	ND	ND	ND
21	2.33	ND	ND	ND
31	3.61	ND	ND	ND

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level.
The means with the same letter at any position were not significantly different ($P > 0.05$) ND: Not detected

3.6. Evaluation of Starter culture used in the manufacture of bio UF-Labneh cheese

Significant differences were noted in the viability of starter culture in the various bio UF-labneh cheese samples, as shown in Table 6. Surprisingly, the data showed that adding GFS flour considerably boosted the viable counts of Streptococcus salivarius *subsp. thermophilus, L. bulgaricus, and L. acidophilus* compared to the control.

Table (6): Viability of starter culture counts (log_{10} CFU/ g) of bio UF- Labneh cheeses fortified with different levels of GFS during storage at 5±1°C.

Cold storage period (days)	Treatments			
	C	GFS_1	GFS_2	GFS_3
	Streptococcus thermophilus (log CFU /g)			
1	7.19 ± 0.005^{Cc}	7.25 ± 0.01^{Db}	7.69 ± 0.02^{Da}	7.37 ± 0.01^{Da}
11	7.83 ± 0.01^{Ad}	8.31 ± 0.005^{Bc}	8.78 ± 0.005^{Ba}	8.54 ± 0.01^{Bb}
21	8.32 ± 0.01^{Bd}	9.58 ± 0.01^{Ac}	9.96 ± 0.01^{Aa}	9.79 ± 0.05^{Ab}
31	5.41 ± 0.02^{Dc}	6.61 ± 0.02^{Cb}	6.87 ± 0.01^{Ca}	6.80 ± 0.02^{Ca}
	Lactobacillus bulgaricus (log CFU /g)			
1	7.04 ± 0.01^{Cd}	7.19 ± 0.005^{Cc}	8.28 ± 0.01^{Ca}	7.26 ± 0.01^{Cb}
11	7.92 ± 0.005^{Ac}	8.72 ± 0.01^{Bb}	8.90 ± 0.05^{Ba}	8.84 ± 0.02^{Ba}
21	8.24 ± 0.01^{Bd}	9.11 ± 0.005^{Ac}	9.52 ± 0.01^{Aa}	9.37 ± 0.01^{Ab}
31	5.31 ± 0.005^{Dd}	6.56 ± 0.005^{Dc}	6.92 ± 0.01^{Da}	6.79 ± 0.01^{Db}
	L. acidophilus (log CFU /g)			
1	7.82 ± 0.01^{Cd}	8.24 ± 0.005^{Cc}	8.94 ± 0.01^{Ca}	8.64 ± 0.005^{Cb}
11	8.54 ± 0.02^{Bd}	9.69 ± 0.005^{Bc}	10.06 ± 0.01^{Ba}	9.85 ± 0.01^{Bb}
21	8.79 ± 0.005^{Ad}	10.11 ± 0.005^{Ac}	10.53 ± 0.01^{Aa}	10.38 ± 0.01^{Ab}
31	6.30 ± 0.005^{Dd}	8.01 ± 0.005^{Dc}	8.68 ± 0.005^{Da}	8.18 ± 0.01^{Db}

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level. The means with the same letter at any position were not significantly different ($P > 0.05$) ND: Not detected

In Table 7, it was found that GFS_2 was the highest in the numbers of both *S. thermophilus*, *Lactobacillus delbrueckii subsp. bulgaricus, and Lactobacillus acidophilus*, where the numbers after 21 days represented 9.96 log cfu/g for *S. thermophilus* while it was 6.87 log cfu/g at the end of the storage period. As for the vital numbers of *L. bulgaricus*, they ranged between 6.92 and 9.52 log cfu/g in the same treatment GFS_2. Regarding *L. acidophilus*, the vital numbers for it were between 8.68 and 10.53 log cfu/g for the treatment of GFS_2. These results agreed with **[11]; [17]; [18]; [27]; [54].**

Among the elements that affect the viability of lactic acid bacteria are the nutrients found in the diet. The viability of *Streptococcus* and *Lactobacillus* is therefore predicted to have increased as a result of the use of plant derivatives in the bio UF-labneh cheese. In addition to other factors, this improved viability that can be linked to the polyphenols, antioxidant, and fiber included in food with a plant origin. This is because GFS is well known for having a high fiber, gum, stabilizer, emulsifier, and other phytochemical content**.** The current research's reported viable numbers of these bacteria can be improved according to He, et al.,**[21].** Due to its role as a fermentable substrate that promotes the growth of lactic acid bacteria, dietary fiber acts as a supplementary source of carbs. This effect of dietary fiber on the survival of lactic acid bacteria in yoghurt mixed with pineapple dietary fiber was previously demonstrated by similar studies by Sah, *et al.***, [41].**

3.7. Evaluation of Tyrosine and tryptophan contents (mg/ 100g) of bio UF-Labneh cheese fortified with GFS

Tyrosine concentration in all treatments gradually grew as the age of the bio UF-Labneh cheese was generated, as shown by the data in Table 7. Similar findings were reported by Ammar **[4].** Tyrosine levels on the first day UF-Labneh varied from 21.33 to 29.84 mg/100 g, and after 31 days in the refrigerator, they grew at a variable rate to 65.23 to 90.35 mg/100 g. Tyrosine was raised in the presence of starter culture, and control treatment (C) had the highest amount of tyrosine. This may be because the starter culture is more active with adding GFS in UF-labneh cheese than in the control treatment (C), according to these findings, which were validated by Ayyad *et al.***, [6**].

As for tryptophan content, it appears that it took the same direction as tyrosine production, GFS treatment recorded the lowest level of tryptophan. On the contrary, the control treatment recorded the highest levels of tryptophan, whether on the first day at 16.49

mg/100g or during the storage period up to 31 days at 83.74 mg/100g.

Throughout the 31 days of ripening, there was a significant difference ($p \leq 0.05$) between the GFS treatments and the C treatments. Tyrosine and tryptophan concentrations generally rose noticeably as the labneh cheese aged, suggesting a rapid method for determining the degree of proteolysis in ripening labneh cheese that reflected the impact of GFS concentration, probiotic bacteria, and ripening length on sensory evaluation. The outcomes lined up with those of Salem et al., **[42]**. On the other hand, it was noted that GFS_3 was the lowest in the amount of tyrosine and tryptophan. This is probably because GFS_3 is higher in antioxidants (TAA) and total phenolic compounds (TOC), which slow down protein degradation, and increase the shelf life of labneh for a longer period. These results agreed [**2]; [11]; [25] ,** and **[28].**

Table (7): Protein proteolysis of of bio UF-Labneh cheeses fortified with different levels of GFS during storage at 5±1°C.

Cold storage period (days)	Treatments			
	GFC	GFS_1	GFS_2	GFS_3
	Tyrosine (mg/100 g cheese)			
1	29.84 ± 0.01^{Da}	25.42 ± 0.02^{Db}	22.18 ± 0.01^{Dc}	21.33 ± 0.03^{Dd}
11	49.75 ± 0.01^{Ca}	42.73 ± 0.03^{Cb}	38.67 ± 0.02^{Cc}	30.65 ± 0.01^{Cd}
21	58.15 ± 0.01^{Bb}	53.76 ± 0.01^{Bd}	59.85 ± 0.01^{Ba}	55.12 ± 0.02^{Bc}
31	90.35 ± 0.05^{Aa}	78.63 ± 0.03^{Ab}	73.76 ± 0.01^{Ac}	65.23 ± 0.03^{Ad}
	Tryptophane (mg/100 g cheese)			
1	16.49 ± 0.04^{Da}	13.8 ± 0.01^{Db}	11.7 ± 0.02^{Dc}	10.9 ± 0.01^{Dd}
11	45.07 ± 0.02^{Ca}	39.40 ± 0.01^{Cb}	36.33 ± 0.03^{Cc}	36.30 ± 0.05^{Cc}
21	56.93 ± 0.03^{Ba}	53.57 ± 0.03^{Bb}	51.64 ± 0.04^{Bc}	50.17 ± 0.02^{Bd}
31	83.74 ± 0.04^{Aa}	77.84 ± 0.04^{Ab}	74.83 ± 0.03^{Ac}	71.65 ± 0.05^{Ad}

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level. The means with the same letter at any position were not significantly different (P > 0.05) ND: Not detected

3.8. Total volatile fatty acids (TVFA) mg100 g^{-1} and Peroxide values (meq oxygen/kg fat) assessment

The results in Table (8), indicated that PV in UF-labneh cheese samples was affected by the addition of GFS. In addition, PV developed at a considerably higher rate in the control treatment (C) throughout the storage period. Peroxide values of all treatments increased through the storage period. At the end of the storage period, C treatment exhibited the highest PV 0.52 ±0.01 (meq oxygen/kg fat). GFS_1, GFS_2, and GFS_3 treatments incorporated recorded, 0.79 ±0.005, 0.72 ±0.01, and 0.68 ±0.005 of PV respectively at the end of the storage period. The stabilization of UF-labneh cheese containing GFS may be due to the presence of a higher concentration of phenolic, antioxidants which inhibited fat oxidation. GFS showed high antioxidant activity in the assay, such as Flavonoids, β- Carotene, Phenolates, and Folates Abd-El-Malek, *et al.*, [**2**].

The total volatile fatty acid profile was shown to be a significant predictor of labneh cheese maturity and lipolysis, rising dramatically as the ripening progressed. Table 8 showed that there was a significant change between treatments ($p \leq 0.05$). GFS_1, GFS_2, and GFS_3 in first day bio UF-labneh cheese varied from 28, 24 and 20 mg100 g^{-1}, respectively, compared to 32 mg100 g^{-1} in C treatment. Notably, TVFA developed significantly after 31 days of ripening. As a consequence, the observed results agreed with those of Salem *et al.*, **[42].**

Table (8): Peroxide value and total volatile fatty acids (%) of bio UF-Labneh cheeses fortified with different levels of GFS during storage at 5±1°C.

Cold storage period (days)	Treatments			
	C	GFS_1	GFS_2	GFS_3
	P.V (mEq/kg)			
1	0.52 ± 0.01^{Da}	0.46 ± 0.01^{Db}	0.43 ± 0.01^{Dbc}	0.40 ± 0.005^{Dc}
11	0.63 ± 0.01^{Ca}	0.54 ± 0.01^{Cb}	0.49 ± 0.005^{Cc}	0.45 ± 0.01^{Cd}
21	0.85 ± 0.01^{Ba}	0.62 ± 0.01^{Bb}	0.59 ± 0.005^{Bbc}	0.56 ± 0.01^{Bc}
31	1.22 ± 0.01^{Aa}	0.79 ± 0.005^{Ab}	0.72 ± 0.01^{Ac}	0.68 ± 0.005^{Ad}
	TVFA%			
1	32.00 ± 0.01^{Dd}	28.00 ± 0.02^{Dd}	24.0 ± 0.01^{Dd}	20.0 ± 0.01^{Dd}
11	38.00 ± 0.01^{Cc}	34.00 ± 0.005^{Cc}	28.00 ± 0.05^{Cc}	24.0 ± 0.02^{Cc}
21	50.00 ± 0.002^{Bb}	48.00 ± 0.01^{Bb}	40.00 ± 0.01^{Bb}	35.00 ± 0.005^{Bb}
31	67.00 ± 0.005^{Aa}	59.00 ± 0.01^{Aa}	48.00 ± 0.05^{Aa}	40.0 ± 0.5^{Aa}

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level.

The means with the same letter at any position were not significantly different (P > 0.05) ND: Not detected

3.9. Syneresis (g of /100g labneh) and water holding capacity (WHC %) of bio UF- labneh cheese

Table 9 showed an inverse relationship between syneresis and WHC%, where it was significantly reduced ($P \leq 0.05$) in syneresis with the addition of GFS, and also during storage in comparison to C treatment. U-F labneh treatments fortified with GFS had considerably greater WHC% ($P \leq 0.5$). And therefore, GFS_3 exhibited the lowest syneresis both of 1 day and after 31 days of storage, at 9.10 ± 0.05, and 7.50 ± 0.01 (g/100g labneh). While C treatment had the greatest syneresis compared to other treatments, 16.40 ± 0.01, and 12.80 ± 0.05 respectively (g/100g labneh). Furthermore, the findings showed that RPS_3 had the greatest WHC% (41.80 ± 0.01, and 35.30 ± 0.01%) at 1 day and after 1 month of storage, followed by GF_2 and GFS_1.

Table 9, the lower synergism of GFS-fortified treatments compared to C treatment is attributed to the interaction of fenugreek protein with milk components and determines their ability to stabilize and emulsify labneh. GFS also contains gums that act as an emulsifier and stabilizer, thus the high WHC value of labneh cheese in treatments containing a higher percentage of GFS can be explained. This was agreed upon by Wani and Kumar **[51].** This could also be attributed to fiber particles in GFS that absorb water from the surrounding protein matrix and will swell, limiting syneresis and increasing WHC Lucey **[32];** Shams El Din, *et al.*, **[43].**

Table(9): Syneresis and water Holding Capacity (WHC) of bio UF- Labneh cheese fortified with different levels of GFS during storage at 5±1°C.

Cold storage period (days)	Treatments			
	C	GFS_1	GFS_2	GFS_3
	Syneresis (g water/100g Labneh)			
1	16.40 ± 0.01^{Aa}	12.60 ± 0.05^{Ab}	10.80 ± 0.01^{Ac}	9.10 ± 0.05^{Ad}

11	14.10 ± 0.05[Ba]	12.30 ± 0.01[Ab]	10.60 ± 0.11[Ac]	9.00 ± 0.01[ABd]
21	13.60 ± 0.01[Ca]	11.8667± 0.03[Bb]	9.30 ± 0.01[Bc]	8.80 ± 0.05[Bd]
31	12.80± 0.05[Da]	10.40 ± 0.01[Cb]	8.90 .01[Cc]	7.50 ± 0.01[Cd]
		WHC (%)		
1	33.40 ± 0.01[Ad]	36.50 ± 0.005[Ac]	39.20 ± 0.01[Ab]	41.80 ± 0.01[Aa]
11	32.8033± 0.008[Bd]	34.90 ± 0.005[Bc]	36.60 ± 0.02[Bb]	39.70 ± 0.02[Ba]
21	31.60 ± 0.005[Cd]	32.40 ± 0.01[Cc]	33.80 ± 0.01[Cb]	37.70± 0.01[Ca]
31	30.10 ± 0.01[Dd]	31.25 ± 0.01[Dc]	31.40 ± 0.01[Db]	35.30 ± 0.01[Da]

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level. The means with the same letter at any position were not significantly different (P > 0.05) ND: Not detected

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3.10. Texture profile analysis (TPA) of bio U-F Labneh cheese

The TPA results of the Labneh cheese textural profile analysis are shown in Figure 3. TPA levels were found to vary considerably ($P \leq 0.05$) across all treatments. The high hardness of GFS has been cited as the reason for its incorporation into the creation of Labneh. The results of the GFS3 therapy were 31.30 ± 0.02 and 15.70 ± 0.01, while the results of the C treatment were 10.10 ± 0.05 and 4.70 ± 0.05. After one day and one month of storage, texture profile analysis showed the same pattern for cohesiveness, springiness, chewiness, adhesiveness, and gumminess. The texture profile analysis results in figure 3 agreed with **[14]; [17]; [43]**.

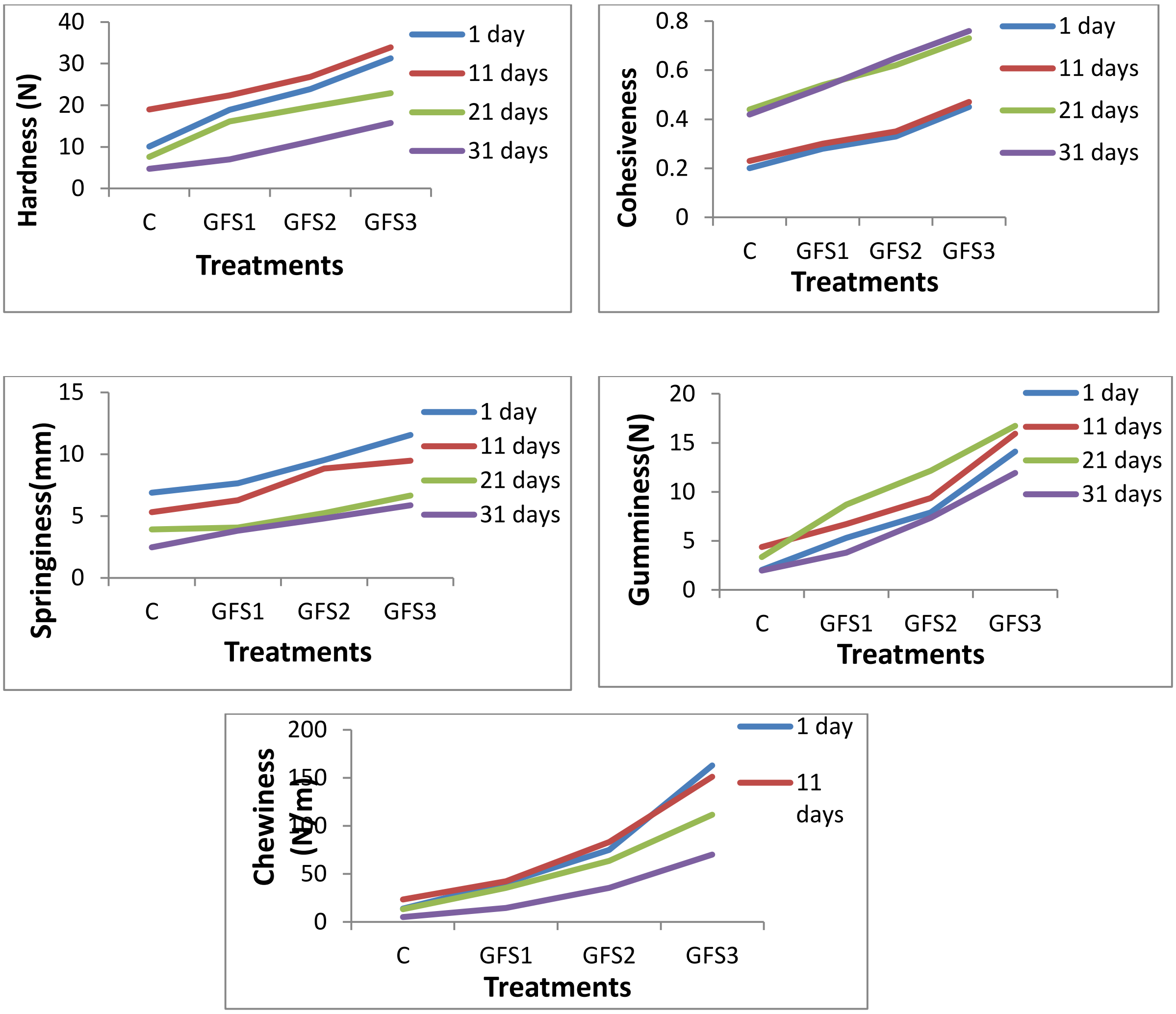

Figure 3. Texture profile analysis of bio UF-Labneh cheeses fortified with different levels of GFS during storage at 5±1°C

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour)

3.11. Sensory evaluation of bio UF- Labneh cheese with GFS

Table 10. depicted the sensory evaluation of bio UF-Labneh cheese with GFS after 31 days of cold storage at 5±1°C. The results revealed that there were substantial variations in the outer appearance, body, texture, aroma, and flavor of bio UF-Labneh samples ($P \leq 0.05$). The results show that the Labneh enriched with GFS, particularly GFS_1 and GFS_2, is similar to the control C in appearance, smoothness, and texture during the first day. But after 11 days of storage and until the end of the storage period, treatments GFS_1 and GFS_2 showed superiority over the control in general appearance and composition, where the texture and composition were more smooth and cohesive, due to the gum, emulsifier, and emulsion contained in the ring that makes the texture more cohesive and smooth. GFS_3 treatment showed the taste of fenugreek seeds clearly as the color was greenish, which makes it different from the color of labneh cheese. These results agreement,**[51].**

Table (10): Sensory evaluation of bio UF-Labneh cheeses fortified with different levels of GFS during storage at 5±1°C.

1. Cold storage period (days)	Treatments			
	C	GFS_1	GFS_2	GFS_3
	Outer appearance (10)			
1	10	10	10	9
11	9	10	10	9
21	8	9	9	9
31	6	8	8	7
	Body & Texture (10)			
1	10	10	10	10
11	9	10	10	10
21	8	9	9	9
31	7	9	9	8
	Aroma& Flavor (10)			
1	10	10	10	9
11	10	10	10	9
21	9	9	9	9
31	6	9	9	7
	Total score (30)			
1	30^{Aa}	30^{Aa}	30^{Aa}	28^{Ab}
11	28^{Bb}	30^{Aa}	30^{Aa}	28^{Ab}
21	25^{Cb}	27^{Ba}	27^{Ba}	27^{Ba}
31	19^{Dc}	26^{Ca}	26^{Ca}	22^{Cb}

C, Control bio UF- Labneh cheese; GFS_1, bio UF- Labneh (0.5% germinated Fenugreek seeds flour); GFS_2,bio UF- Labneh (1.0% germinated Fenugreek seeds flour);PRS_3, bio UF- Labneh (1.5% germinated Fenugreek seeds flour). A, B, C,....: Means of possess the storage period. a,b,c,d: The factor of GFS level.
The means with the same letter at any position were not significantly different ($P > 0.05$) ND: Not detected

4. Conclusion

Based on the findings of this study, it is safe to conclude that seed flour made from germinated fenugreek seeds can be used to create novel functional UF-labneh cheese. The fiber and phytochemical nutrients are present in these germinated seeds flour.GFS flour can improve the viability of starter culture since it acts as a fermentable substrate for LAB and it also has a significant effect on the number of probiotic bacteria.

With its addition, TPC and TAA increased without its sensory acceptability declining. In addition, Labneh cheese fortified with germinated fenugreek seeds flour showed significantly higher mineral content and vitamins increased through the incorporation of these seed flours. Moreover, the results showed that GFS had a significant effect on the composition and rheological properties of UF-labneh cheese during storage. For all of the above, we recommend the use of germinated fenugreek seeds flour at a rate of 0.5 and 1% in the manufacture of new functional fermented milk products with long shelf life.

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