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Research Article

Preparation and Properties of Stirred Yogurt Supplemented with Powdered Doum (*Hyphaene thebaica*) Fruit

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Abstract:

Recently, there has been a surge of interest in enhancing traditional stirred yogurt to increase demand for healthy, high nutritional value, and delicious dairy products. Doum fruit, which contains carbohydrates, different minerals, antioxidants, and metabolites such as tannins, saponins, steroids, glycosides, terpenes, and terpenoids, contains necessary nutrients and functional characteristics. Consequently, there has been an enhancement of the characteristics of Stirred Yogurt using doum fruit. In this study, Doum fruit (doum powder 2%, 4%), (doum extract 0.2%, 0.4%) was employed in yogurt, as a good source of phenolic compounds, flavonoids, and minerals such as iron, potassium, calcium, and magnesium. Stirred yogurt fortified with Powdered doum fruit gained in a shorter fermentation time than Yogurt by using doum extract, improving yogurt's viscosity and water-holding capacity. Moreover, there was an increase in flavonoids and phenolic compounds and a general boost in antioxidant activity when Yogurt using doum extract. By using doum fruit in yogurt production, its properties can be enhanced while preserving its biologically active antioxidant characteristics in comparison to non-fortified yogurt.

1. Introduction

Yogurt, a fermented dairy product, is manufactured by lactic acid fermentation via symbiotic bacteria cultures such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. Yogurt had higher nutritional value, boasting increased levels of protein, vitamins such as B12, B6, and B2, and minerals such as calcium, magnesium, potassium, and zinc. (Bakircioglu et al., 2018). Yogurt is widely regarded as a natural and healthy probiotic food. Many studies have suggested that yogurt could help in digestion, improve metabolic health, enhance immunity, and potentially reduce the risk of cancer development by inhibiting oncogenic processes (Holden et al., 2008).

Fortifications of dairy products with natural substances promote fortified products' physicochemical characterizations and nutritive values (Jalal et al., 2015). Fortified yogurt with natural ingredients has included various objectives such as maintaining the nutritional quality of yogurt, addressing specific deficiencies in certain groups (such as the elderly, vegetarians, and pregnant women), adding nutritional value to products for commercial purposes, and providing technological functions in yogurt processing (Nestle, 2013). Hence, the present research aimed to enhance yogurt with doum fruit (*Hyphaene thebaica*) doum is a sacred plant in Egyptian and other African cultures and belongs to the Arecaceae family (Saber et al., 2023).

Doum palm *(Hyphaene thebaica)* is native to Egypt sub-Saharan Africa and West India. In Egypt, the doum palm has been cultivated since ancient times and it is known as the doum or gingerbread palm. Doum fruit is rich in active compounds, including polyphenolic flavonoids such as myricetin, kaempferol, quercetin, and myricitrin, as well as phenolic compounds like ellagic acid, gallic acid, caffeic acid, and Ferulic acid (Abdel-moniem et al., 2015). The presence of flavonoids in Hyphaene thebaica fruit contributes to its antimicrobial properties. Flavonoids and polyphenols found in Doum fruit can combat peroxy radicals that lead to the degradation of fat bonds in cell membranes. These compounds can neutralize free radicals, preventing them from causing further damage to the body (Kassim, 2015). The Phenolic compounds in *Hyphaene thebaica* exhibit a range of biological activities, such as antimicrobial, anticancer, hyperlipidemic, antioxidant, anti-inflammatory, and antidiabetic effects (Abdallah, 2021).

Additionally, doum powder contains essential minerals Such as potassium, sodium, calcium, magnesium, and phosphorus, according to various studies. It is also a source of vitamin B complex, carbohydrates, moisture content, crude fiber, ash content, protein, fat, and vitamins, particularly niacin, folic acid, pyridoxine, riboflavin, and thiamin all beneficial for health. It is recognized for its nutritional qualities and potential applications in the food industry (Islam et al., 2022). Furthermore, doum powder exhibits strong antibacterial properties against both gram-positive and gram-negative microorganisms (Aboshora et al., 2019).

Doum fruit extract is recognized as a primary source of phenols and flavonoids, possessing significant

antioxidant and anticancer properties. Furthermore, research has indicated that the aqueous extract of *Hyphaene thebaica* also exhibits antioxidant activity due to its high concentration of water-soluble phenolic compounds (Taha et al., 2020). Aqueous extracts from the doum palm have been shown to increase the viability and performance of specific dairy starter cultures commonly utilized in the production of various dairy products, particularly probiotics (Hassan and Aumara, 2005).

Furthermore, Doum extracts could serve as fiber and antioxidant supplements with desirable physicochemical properties and sensory attributes (Nassef et al., 2022). So, this investigation aimed to evaluate the use of powdered doum fruit as a potential ingredient of dietary fiber, mineral, and natural antioxidants in stirred yogurt.

2. Materials and Methods

2.1. Materials

Fresh cow's milk (moisture 87.45%, fat 4.5%, total protein 3.1%, ash 0.77, total solid 12.55%, pH 6.8, and acidity 0.18%) was obtained from a local farm in Egypt. The yogurt culture utilized in the production consisted of *Streptococcus thermophilus and Lactobacillus delbrueckii sub ssp. bulgaricus* (DVS), obtained from Hansen Copenhagen Laboratories in Denmark. Carboxy Methyl Cellulose (CMC) utilized in the research was obtained from Misr Food Additives Company (MIFAD), Egypt. Doum fruits were purchased from the local market in Tanta, Egypt.

Preparation of Powdered doum fruit (PDF)

The process of preparing the powdered doum fruit (PDF) involved a careful selection of intact and uniformly sized doums, free from fungal contamination or external cracks. The kernels were separated from the inedible parts after being washed with tap water. The mesocarp was cut into equally small pieces, meticulously extracted, and dried in an air oven (Shellab-Model 1350FXMade in USA) at 40±2°C for approximately 48 hours. Subsequently, the dried mesocarp was finely ground into powder using a mechanical laboratory grinder and was sieved through a 35-mesh (0.425 mm) sieve. The resulting flour was then packed into polyethylene bags and stored at 4±1 °C until used.

Preparation of Doum Extract (DE)

According to (Karaaslan, *et al.*, 2011) with some modifications 50 g of the doum powder was mixed with 100 mL of acidified methanol, then the mixture was left at 4 °C for overnight incubation. The mixture was filtered by using No. 1 Whatman filter paper and residue was washed with acidified methanol-HCl until it became colorless. 50mL of DE was separated to determine polyphenol content by HPLC. The remaining portions were concentrated by a rotary evaporator at 50 °C and dried by freeze-drying.

Stirred yogurt manufacture

Stirred Yogurt was processed in the dairy pilot laboratory of the food science and technology department, at Tanta University. Stirred yogurt was manufactured according to (Tamime and Robinson, 2007). Fresh cow's milk was heat treated at 65 °C for 30 min then divided into five treatments. Control yogurt without any additives. T1 yogurt fortified with DP 2%. T2 yogurt fortified DP addition 4%. T3 yogurt fortified with 0.2% DE. T4 yogurt fortified with 0.4% DE. All treatments had 2% sugar, and 0.02% carboxymethyl cellulose, for stabilization. Starter culture was added (2%) at 42 ± 2°C and then packaged in sterilized plastic cups with a capacity of 100 ml. The treatments were then incubated at 42°C until reaching a pH of 4.67, followed by cooling to 4°C. The samples were stored for 15 hours, and analyses were conducted at 0, 7, and 14 days.

Three replicates were used for each treatment before completing the analysis; the gel was broken by shaking a glass rod 10 times clockwise and 10 times counterclockwise.

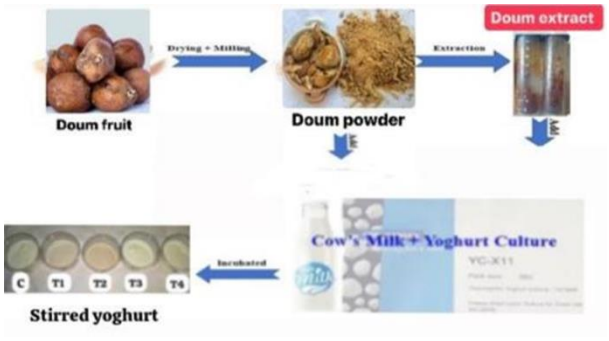

Fig. 1. A simple schematic representation of the manufacture of stirred yogurt fortified with doum powder and doum extract

2.2. Methods of analysis

2.2.1. Chemical analysis

Total solids (TS), total protein (TP), ash, Fat, and titratable acidity as lactic acid were identified by the earlier study (Thiex, *et al.*, 2012). pH values were determined with JENCO pH meter model 1671, USA.

2.2.2. Determination of minerals

Minerals were determined using an Atomic Absorption Spectrophotometer (Model 2380, Japan) was utilized to measure the concentrations of minerals including Ca, Mg, and Fe following the AOAC (2003) protocol. Meanwhile, the Flame Photometer (Model PE P7, England) was employed to determine the concentration of K.

2.2.3. Color measurement

Minolta CR400 colorimeter (Japan, Minolta, and Osaka) was used to evaluate the color values samples of stirred yogurt. The color dimensions L*, a*, and b*, namely lightness (L*), redness (a*), and yellowness (b*) were measured. Delta E (ΔE), the total color change compared to the control, was calculated based on the following equation (Ji et al., 2022):

$$\Delta E=\sqrt{(L1-L2)2+(a1-a2)2+(b1-b2)2}$$

2.2.4. Antioxidant activity

Free radical scavenging activity (RSA) of the yogurt samples was determined using DPPH, the yogurt extract samples were mixed in a 1:1 ratio (v/v) with 0.1 mM DPPH dissolved in methanol. The mixture was then left at room temperature in the dark for 30 minutes, and distilled water was used as a blank sample. The scavenging effectiveness was determined using the formula: Scavenging activity (%) = (A0 - AS) / A0 × 100, where A0 and AS represent the absorbances at 520 nm for the blank and the samples, respectively, as described by (Li et al., 2015).

2.2.5. Determination of total phenolics and flavonoids

2.2.5.1. Total phenolic: The total phenolic content (as % gallic acid) was determined in the filtrate by Folin- Ciocalteu reagent. One gram of the yogurt sample was supplemented with 9 mL of 70% methanol and was centrifuged at 4000 revolutions for 15 minutes. Then, 125 µL of the resulting supernatant was mixed with 150 µL of Folin-Ciocalteu reagent in a 1:1 ratio. Sodium carbonate (2.25 mL) was added with a pipette, and the mixture was incubated at 25°C for 30 minutes in a dark room. The absorbance was then measured at 750 nm, and the total phenolic content was determined based on the calibration curve. The results were reported as mg of gallic acid equivalent per gram of dry weight, following the method described by (Gulcin, 2020).

2.2.5.2. Total flavonoids: one gram of the yogurt sample was supplemented with 9 mL of 70% methanol, and centrifuged at 4000 revolutions for 15 minutes. One milliliter of the resulting supernatant was taken, and 1 mL of 2% AlCl3 was added to it. The mixture was incubated for 10 minutes at room temperature in a dark place, and the absorbance was measured at 520 nm. The total flavonoid content was calculated from the titration curve, and the results were expressed as mg per gram of dry matter with modifications from the method described by (Gulcin, 2020).

2.2.6. Determination of viscosity:

Viscosity expressed in the samples was determined by using a Brookfield viscometer (model DV-II, Cana-da) fitted with four spindles to measure the apparent viscosity at 10±2 °C. FHTB. Samples were subjected to select shear rates ranging from 3.0 to 50.0 S1 of the bullish curve. Apparent viscosity was expressed in Pascals (Pa).

2.2.7. water-holding capacity (WHC)

Water-holding capacity (WHC) was determined according to (Robertson, *et al.*,2000) with some modifications. Twenty-five milliliters of buffer phosphate (1 M, pH 6.3) were added to 250 mg of dry sample, stirred, and left at room temperature for 1 h. After centrifugation, the residue was weighed. The WHC was expressed as a gram of water held per gram of sample.

2.2.8. Sensory evaluation

The sensory properties Of the control and other stirred yogurt treatments were evaluated based on the senses Scheme presented by Fresh and stored samples, which were assessed by ten arbitrators from the researchers of the Dairy Chemistry Department at the Animal Production Research Institute of the Agricultural Research Center specializing in sensory arbitration (Kailasapathy, 2006).

2.3. Statistical analysis

Triplicate measurements were taken for all parameters, and results were presented as means of standard errors. The SPSS statistical software package for analysis of variance and Duncan's test (SPSS 20 for Windows, SPSS INC., IBM, New York) was used.

3. Results and Discussion

3.1. Chemical properties of fortified stirred yogurt

3.1.1. Total solids content

Table (1) indicates the total solids content of fortified stirred yogurt during the storage period. Data showed that increased significantly with increasing the concentration of doum powder. The highest mean value was (17.76%) in (T2) containing 4 % DP and the lowest (14.52 %) was recorded in (C) at fresh. This is due to an increase in the doum palm fruit powder levels, and the total solids content of fortified yogurt increased (Aumara and Hassan,2018). Additionally, the storage period caused TS to increase in all treatments. This was more observed in (T2) which had (18.31%). This increase may be due to the evaporation of some moisture during the storage period (Abd-El-Tawab, 2012).

3.1.2. Protein content

Table (1) revealed the total protein content of fortified stirred yogurt during the storage period. Results illustrated that there was a significant rise in protein content in convenience percentage with doum powder levels in fortified samples. T2 had the highest content (5.60%) compared with other treatments. This may be due to the total nitrogen content increased by increasing the rate of addition of Doum powder fruit that had high content of protein (Aumara and Hassan, 2018). Furthermore, TP % increased in all treatments during the storage period. This was more observed in (T2) which had 5.64%.

3.1.3. Ash content

The ash content of fortified stirred yogurt during the storage period is shown in Table (1). T2 and T1 had the highest ash content 1.02%, and 0.94 %, respectively at fresh. In contrast, there were no significant differences between the other treatments. This is due to doum fruit having high levels of minerals such as potassium, sodium, calcium, and magnesium. Also, ash content increased in all treatments during the storage period of 7 and 14 days. This was more observed in treatment T2 which had 1.12%. Similar results were reported by (EL-Nagar and Brennan, 2001) on yogurt samples.

3.1.4. Fat content

Table (1) indicate the Fat content of fortified stirred yogurt. T2 by followed T1 had the highest fat % 3.77%, and 3.72 %, respectively at fresh. This may be due to the Acetaldehyde and diacetyl contents of fortified samples increased by increasing the level of Doum palm fruit addition (Aumara and Hassan, 2018). furthermore, fat % increased in all treatments during the storage period. This was more observed in T2 compared with other treatments. These results are in agreement with those obtained by (Aumara, 2000) in probiotic fermented milk as a result of cold storage period.

Table 1. Chemical properties of fortified stirred yogurt

Chemical properties	Storage (days)	Treatments				
		C	T1	T2	T3	T4
Total Solids (%)	Fresh	14.52 ± 0.03^{Cc}	15.81 ± 0.01^{Cb}	17.76 ± 0.05^{Ca}	14.59 ± 0.03^{Cc}	14.71 ± 0.01^{Cc}
	7	14.67 ± 0.01^{Bc}	16.02 ± 0.01^{BB}	17.56 ± 0.11^{Ba}	14.66 ± 0.006^{Bc}	14.86 ± 0.02^{Bc}
	14	14.95 ± 0.02^{Ad}	16.31 ± 0.008^{Ab}	18.31 ± 0.03^{Aa}	14.96 ± 0.02^{Ad}	15.29 ± 0.03^{Ac}
Total Protein (%)	Fresh	5.11 ± 0.01^{Cc}	5.40 ± 0.01^{Cb}	5.60 ± 0.04^{Aa}	5.13 ± 0.03^{Cc}	5.17 ± 0.06^{Cc}
	7	5.22 ± 0.01^{Bd}	5.57 ± 0.02^{Bb}	5.70 ± 0.14^{Aa}	5.22 ± 0.15^{Bd}	5.28 ± 0.008^{Bc}
	14	5.44 ± 0.01^{Aa}	5.75 ± 0.04^{Aa}	5.64 ± 0.11^{Aa}	5.39 ± 0.01^{Aa}	5.41 ± 0.02^{Aa}
Ash (%)	Fresh	0.89 ± 0.001^{Cc}	0.94 ± 0.008^{Cb}	1.02 ± 0.02^{Aa}	0.89 ± 0.003^{Cc}	0.92 ± 0.01^{Cc}
	7	0.91 ± 0.01^{Bb}	0.96 ± 0.003^{Bb}	1.02 ± 0.04^{Aa}	0.93 ± 0.01^{Bb}	0.99 ± 0.01^{Bb}
	14	0.93 ± 0.003^{Ab}	1.09 ± 0.003^{Aa}	1.12 ± 0.13^{Aa}	0.95 ± 0.01^{AB}	0.97 ± 0.01^{Ab}
Fat (%)	Fresh	3.63 ± 0.05^{Cc}	3.72 ± 0.01^{Cb}	3.77 ± 0.01^{Ca}	3.62 ± 0.003^{Cc}	3.61 ± 0.01^{Cc}
	7	3.71 ± 0.01^{Bc}	3.79 ± 0.003^{Bb}	3.86 ± 0.01^{Ba}	3.70 ± 0.01^{Bc}	3.72 ± 0.003^{Bc}
	14	3.75 ± 0.003^{Ac}	3.83 ± 0.003^{Ab}	3.90 ± 0.01^{Aa}	3.74 ± 0.01^{Ac}	3.76 ± 0.01^{Ac}

Data are means ± S.E. *C: Control stirred yogurt; T1: fortified stirred yogurt with 2% T2: fortified stirred yogurt with 4% DP; T3: fortified stirred yogurt with 0.2% DE; T4: fortified stirred yogurt with 0.4% DE. Different small superscripts due to treatments and averages with different capital superscripts due to storage period differed significantly ($P \leq 0.05$).

3.2. physical properties of fortified stirred yogurt

3.2.1. PH values

The pH values of stirred yogurt are revealed in Table (1). T4 and T3 samples had significantly lower pH values than the other treatments through 14 days of the storage period, 4.43, and 4.45%, respectively. On the other hand, T1, T2, and C were recorded at 4.46%, 4.47, and 4.49, respectively. This may be due to the high acidity of Doum extract (Abd El-Rashid and Hassan, 2005). These results are in agreement with the results, reported (El-Kholy, 2015).

3.2.2. Acidity %

Table (2) indicates t the acidity of stirred yogurt. Data showed that T4 and T3 had significantly higher acidity than the other treatments. This may be due to the extract of doum fruit containing several amino acids such as leucine, phenylalanine, aspartic, and glutamic acid which promote increased acidity (Aamer, 2016).

Table 2. Physical properties of fortified stirred yogurt

Physical properties	Storage (day)	Treatments				
		C	T1	T2	T3	T4
pH value	Fresh	4.80 ± 0.01^{Aa}	4.75 ± 0.06^{Ab}	4.73 ± 0.00^{Ab}	4.70 ± 0.03^{Ac}	4.69 ± 0.06^{Ac}
	7	4.71 ± 0.03^{Ba}	4.68 ± 0.03^{Bb}	4.67 ± 0.05^{Bb}	4.64 ± 0.03^{Bc}	4.61 ± 0.05^{Bd}
	14	4.49 ± 0.05^{Cc}	4.46 ± 0.03^{Cb}	4.47 ± 0.05^{Cb}	4.45 ± 0.00^{Ca}	4.43 ± 0.06^{Ca}
Acidity (%)	Fresh	0.57 ± 0.03^{Cab}	0.55 ± 0.02^{Cb}	0.55 ± 0.01^{Cb}	0.56 ± 0.00^{Ca}	0.57 ± 0.03^{Ca}
	7	0.61 ± 0.01^{Cb}	0.62 ± 0.03^{Bc}	0.66 ± 0.01^{Bb}	0.65 ± 0.00^{Bb}	0.68 ± 0.05^{Ba}
	14	0.69 ± 0.03^{Ad}	0.73 ± 0.03^{Ac}	0.76 ± 0.01^{Ab}	0.75 ± 0.03^{Ab}	0.78 ± 0.03^{Aa}

*See legend to Table 1 for details.

3.3. Fermentation time of fortified stirred yogurt

Figure (2) illustrates the fermentation time of fortified stirred yogurt. Data revealed that after 180 min in the incubation period, T1 reaches pH value 4.70 firstly, followed by T2 reaching pH 4.80, then C, T3, and T4, respectively. This may be due to the doum powder containing many phenol polyphenol acids that promote

acidity and short fermentation time (Abdel-moniem et al., 2015). Additionally, extracts of doum fruit contain high levels of phenols and flavonoids, which have significant antibacterial activities (Atito, *et al.*, 2019). Thus, it affected the growth of the starter and led to a long fermentation time.

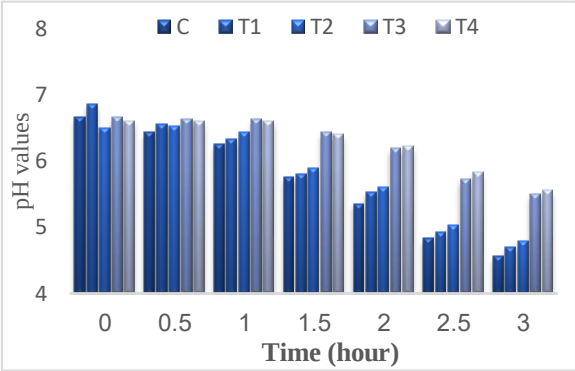

Fig. 2. Fermentation time of fortified stirred yogurt.

3.4. DPPH scavenging activity (%) of fortified stirred yogurt

The function of an antioxidant is to eliminate free radicals by providing hydrogen to a free radical, causing its conversion to a less reactive species. By adding hydrogen, the electron responsible for radical reactivity is removed (Abou–Elalla, 2009). Changes in the antioxidant activity of stirred yogurt from different treatments of powdered and doum extract during the storage period shown in Fig (3). T4 (42.39%) and T3 (37.39%), respectively had the highest DPPH %, then T2 (28.48%) and T1 (25.36 %), respectively compared with C (13.66 %), at fresh storage period. This may be due to the correlation between the concentration of the doum extract and the inhibition percentage (Eldahshan et al., 2008 & 2009). Contrastingly, during the storage period, the DPPH % decreased in all yogurt treatments, with a greater reduction observed in the C. This could be due to the reduction in the viability of some bacteria caused by the storage period, leading to a decrease in the antioxidant activity of bacteria in yogurt for all treatments (Shori et al., 2022).

Fig. 3. DPPH scavenging activity (%) of fortified stirred yogurt.

3.5. Total phenolic and flavonoid content of stirred yogurt

Fig. 4 and Fig.5 illustrate the total phenolic and flavonoid (TFC) and Total phenolic content (TPC) of fortified stirred yogurt. Data demonstrate that T4, and T3 respectively had the highest TPC and TFC %, compared with other treatments. This is attributed to the doum fruit extract a primary source of phenols and flavonoids, possessing significant antioxidant and anticancer properties. This is also due to the abundance of water-soluble phenolic compounds present in the extract (Hsu et al., 2006). During the storage period, all yogurt treatments experienced a reduction in their total phenolic and flavonoid content percentage, C sample showing the greatest reduction. This is due to the LAB bacteria culture hydrolyzing polyphenols to aromatic acids like phenylacetic, phenyl propionic, phenyl valeric, and benzoic acids (Manach et al., 2004).

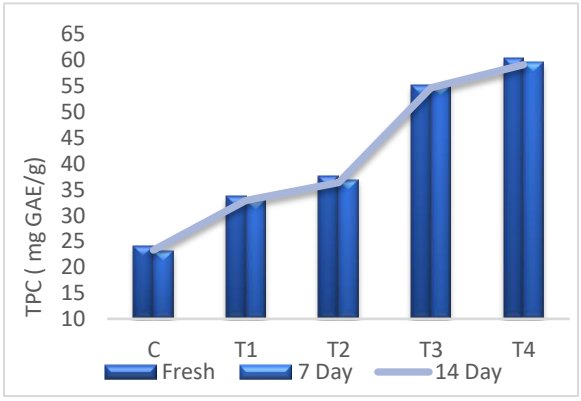

Fig. 4. Total phenolic content of stirred yogurt

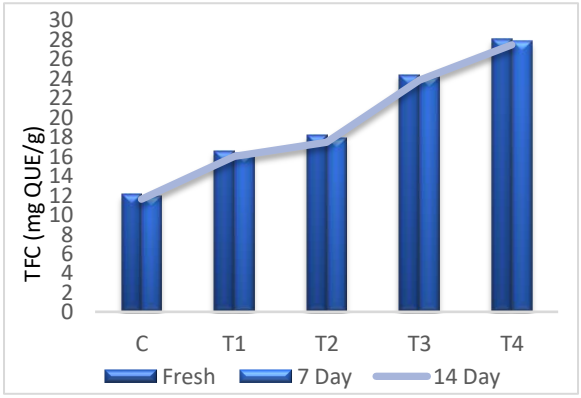

Fig. 5 Total flavonoid content of stirred yogurt

3.6. Mineral content of fortified stirred yogurt

Table (4) shows the minerals of stirred yogurt fortified with powdered and doum extract at various percentages. findings indicated that T2, had the highest content of K, Mg, Fe, and Ca, respectively compared to the other treatments. K content was 50.54 mg/100 g, which has a significant role in controlling high blood pressure as reported by Aremu et al. (2006). (Mg) was 19,44 mg/100 g and is necessary for the functioning of nearly 300 enzymes in the body. Iron content was 1.53mg/100 g and is required for hemoglobin, which transports oxygen to body tissues, as well as being a component of many proteins and enzymes. (Ca) was found to be 0.99 mg/100g.

Table 4. Mineral elements of fortified Stirred yogurt during the storage period

Minerals (mg/100g DM)	Treatments				
	C	T1	T2	T3	T4
Fe	0.39±0.003^{c}	0.85±0.008^{b}	1.53±0.02^{a}	0.40±0.015^{c}	0.40±0.008^{c}
Ca	0.79±0.003^{c}	0.94±0.005^{b}	0.99±0.008^{a}	0.79±0.008^{c}	0.81±0.006^{c}
K	20.23±0.01^{c}	44.10±0.04^{b}	50.54±0.2^{a}	20.26±0.003^{c}	20.28±0.018^{c}
Mg	11.90±0.04^{c}	16.29±0.008^{b}	19.44±0.07^{a}	11.91±0.015^{c}	11.95±0.01^{c}

*See legend to Table 1 for details.

3.7. Color determination

The effects of powdered doum and doum extract on the color parameters of Stirred yogurt are shown in Table 5. Data in Table 5 demonstrate that the L* value (lightness) decreased with the addition of doum powder. Also, the +b* value (yellowness) decreased with the addition of

Doum extract, while the +a* (redness) values increased as doum powder ratios increased in stirred yogurt as compared with treatments doum extract and control, these results agree with the results (El-Kholy,2018)

Table 5. Color properties of fortified Stirred yogurt during the storage period

Color Properties	Treatments				
	C	T1	T2	T3	T4
L*	88.23±0.05^{a}	82.43±0.06^{c}	77.96±0.3^{d}	87.17±0.09^{b}	86.89±0.02^{b}
a *	-3.27±0.04^{e}	-2.16±0.009^{b}	-1.86±0.01^{a}	-2.79±0.01^{d}	-2.58±0.04^{c}
B *	8.18±0.02^{e}	9.80±0.03^{b}	10.10±0.02^{a}	8.48±0.04^{d}	8.83±0.008^{c}

*See legend to Table 1 for details.

3.8. Viscosity and water-holding capacity (WHC) of stirred yogurt

The apparent viscosity and water-holding capacity of stirred yogurt during the storage period is revealed in Fig.6 and Fig.7. Data indicated that there were significant differences between all treatments at fresh, with decreasing values observed in all treatments during the storage period. T2 exhibited the highest apparent viscosity and water-holding capacity results, 252.00 and 64.38, respectively, compared with C at 227.33 and 57.02, and T3 at 218.66 and 57.99, respectively. The increase in the apparent viscosity of stirred yogurt containing doum powder may be due to its high content of fiber characterized by its high WHC (Abd El- Rashid and Hassan, 2005).

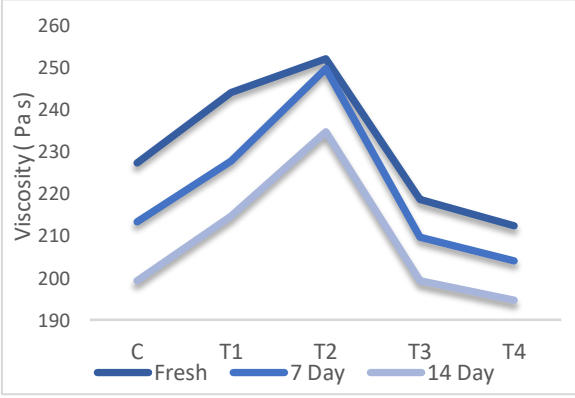

Fig. 6. Viscosity of fortified stirred yogurt during the storage period

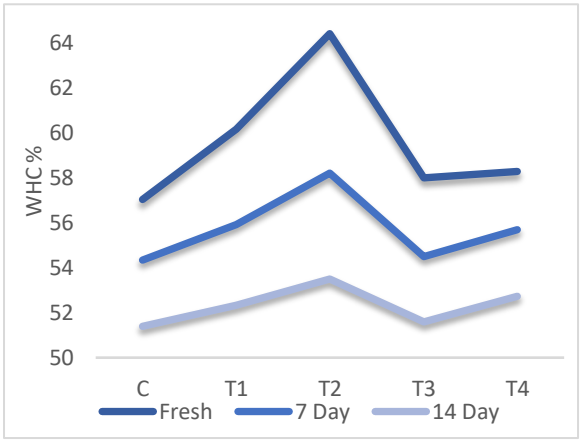

Fig. 7. water-holding capacity (WHC) of fortified stirred yogurt during storage period.

3.9. Sensory evaluation of fortified stirred yogurt

Table (6) revealed the results of a sensory evaluation of fortified stirred yogurt. Data reveal that the panelists preferred T4 followed by T3 and then T2 and T1, and finally, C based on flavor. The flavor ratings at the fresh, and during storage periods were 47.40, 47.55, 46.30 and 45.65, 45.66, 45.45 and 45.05, 45.50, 43.60 and 44.35, 44.95, 44.20 and 42.57, 43.45, 39.40, respectively. There were no significant differences observed in body and texture in T1 & T3 and C compared to T4 and T2. The results were 34.40, 34.00, 33.10 and 34.95, 34.80, 33.90 and 34.40, 33.60, 32.50 and 35.05, 34.55,32.80 and 31.95, 31.95, 29.05, respectively.

This may be attributed to the Doum palm fruit flesh possesses good functional properties as its high water or oil absorption capacity (Aboshora et al., 2014).

Water absorption characteristics represent the ability to associate with water, while oil absorption characteristics reflect emulsifying capacity. (Kaur, et al.,2013) reported that the ability of flour to absorb water and oil may help to improve the binding structure, enhance flavor retention, and improve mouthfeel. Similar results were observed by (Abd El-Rashid and Hassan, 2005) they reported that ice cream prepared in the presence of 3 % doum powder was characterized by creamy color, acceptable flavor, and a description of soft body & texture with good nutritional value of fiber and higher scores of sensory parameters. However, significant differences were observed in appearance between all treatments where C was more accepted by arbitrators, than T3 compared to the other treatments. The results were 9.70, 9.30, 8.65, and 9.25, 9.20, 8.75, respectively.

Table (6): Sensory evaluation of fortified stirred yogurt during the storage period

Properties	Storage (day)	Treatments				
		C	T1	T2	T3	T4
Flavor (50)	Fresh	42.57±0.25^{Ae}	44.35±0.2^{Bd}	45.05±0.21^{Ac}	45.65±0.1^{Ab}	47.40±0.2^{Aa}
	7 Day	43.45±0.2^{Ac}	44.95±0.1^{Ab}	45.50±0.26^{Ab}	45.66±0.22^{Ab}	47.55±0.3^{Aa}
	14 Day	39.40±0.3^{Bd}	44.20±0.2^{Bc}	43.60±0.28^{Bc}	45.45±0.1^{Ab}	46.30±0.3^{Aa}
Body and Texture (40)	Fresh	34.40±0.2^{Ab}	34.40±0.2^{Ab}	31.95±0.2^{Ac}	34.95±0.2^{Ab}	35.05±0.3^{Aa}
	7 Day	33.60±0.25^{Bc}	34.00±0.2^{Ab}	31.95±0.1^{Ad}	34.80±0.2^{Aa}	34.55±0.2^{Ab}
	14 Day	32.50±0.28^{Ca}	33.10±0.3^{Ba}	29.05±0.4^{Bb}	33.90±0.4^{Ba}	32.80±0.23^{Ba}
Appearance (10)	Fresh	9.70±0.08^{Aa}	7.95±0.1^{Ad}	6.30±0.2^{Be}	9.25±0.03^{Ab}	8.00±0.08^{Cc}
	7 Day	9.30±0.1^{Ba}	7.70±0.1^{ABb}	6.55±0.2^{ABc}	9.20±0.1^{Aa}	9.00±0.1^{Aa}
	14 Day	8.65±0.1^{Ca}	7.45±0.17^{Bb}	6.95±0.1^{Ac}	8.75±0.1^{Ba}	8.75±0.8^{Ba}

*See legend to Table 1 for details.

3.10. Sensory evaluation of fortified stirred yogurt during the storage period

Fig. 8 revealed the sensory evaluation of stirred yogurt during the storage period (flavour, body&texture, and appearance). The data indicate that the panelists preferred treatment T4 first, followed by T3, and then T1. This trend may be attributed to Doum fruits leading to an improvement in the sensory properties of synbiotic-flavored fermented skim milk drinks (Khider et al., 2022).

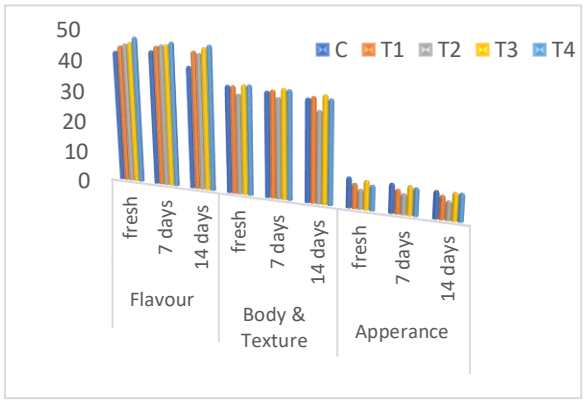

Fig. 8. Total Sensory Analysis of fortified stirred yogurt.

5. Conclusions

Fortification of stirred yogurt with powdered doum and doum fruit extract enhances antioxidant activity and overall acceptability of the fortified yogurt. Additionally, the results revealed that using 0.4% DE in stirred yogurt causes high levels of antioxidants and sensory properties. While using 4% DP had high levels of rheological properties. This approach can lead to a competitive product in the market. Future research on this topic will focus on using fruits, which are rich in fiber, natural antioxidants, and minerals, to increase the nutritional value of fermented dairy products.

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