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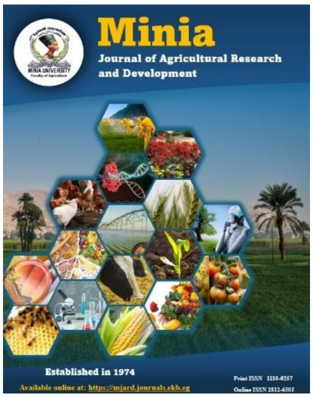

EFFECT OF CARRAGEENAN ON THE PHYSIOCHEMICAL AND TEXTURAL PROPERTIES OF CAMEL MILK YOGHURT

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ABSTRACT

This study aimed to evaluate the effect of adding carrageenan to camel milk to manufacture yoghurt compared to cow milk yoghurt. The results indicated that yoghurt made from camel milk showed a lower pH value, higher titratable acidity, vitamin (C), DPPH activity and carbonyl compounds and weaker curd strength than cow milk yoghurt. However, the addition of carrageenan as a stabilizing agent significantly (P <0.05) improved the gel firmness and reduced whey syneresis. The water holding capacity (WHC) increased while syneresis decreased over storge in all samples. Also increased carbonyl compounds and antioxidant activity was increased. The viable counts of lactic acid bacteria (LAB) (>10^7 cfu/mL) showed only slight decreases throughout storage, with a small initial drop during the first few days followed by stabilization. Sensory evaluation of fermented camel milk with carrageenan focused on optimizing its desirable sensory attributes, such as body, texture, and colour, to enhance its market appeal. Addition of carrageenan (1.5%) to camel milk improved firmness and sensory properties.
Keywords: Camel milk, Carrageenan, yoghurt.

INTRODUCTION:

Camel milk has received increasing attention in recent years due to its high nutritional and therapeutic value **(Muthukumaran *et al.*, 2022).**

Camel milk is generally an opaque white colour and has a faint sweetish odor and sharp taste; sometimes it can be salty **(Abbas, 2013; Atwaa *et al.*, 2022).** It's opaque white colour because the fat is finely homogenized throughout the milk and large casein micelle size **(Omar *et al.*, 2018)**.

The therapeutic effect of camel milk may be attributed to the presence of bioactive proteins, lysozymes, lactoferrin, immunoglobulins, LactoPeroxidese and to the generation of various bioactive peptides upon digestion **(Muthukumaran *et al.*, 2022) .** Camel milk and its derivatives were used for type 2 diabetes **(El-Khashab, *et al* 2023; Ebaid *et al* 2015)**

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Health benefit potentials of camel milk are attributed to presence of nutritional and physiological several bioactive components **(Muthukumaran *et al*., 2022)**.

Nevertheless, yoghurt made from camel milk often exhibits weak texture, poor gel formation and excessive whey separation because camel milk contains more whey protein, lower casein. The camel milk contains high percentage of β-casein (represent > 40% of total casein), coupled with lower κ-casein content led to a weaker protein network during cheese production **(Warakaulle *et al*., 2025).** These characterizations make camel milk difficult to obtain a firm and stable yoghurt gel.

Carrageenan, a natural polysaccharide extracted from red seaweed, can increase viscosity, improve water holding capacity and enhance the textural quality of fermented milk. Therefore, the aim of this study was to evaluate the effect of carrageenan addition on the physicochemical, antioxidants and sensory properties of fermented camel milk.

MATERIALS AND METHODS:

1- Materials:

1-1- Chemicals:

All of the analytical-grade chemicals used in this investigation were provided by Prolabor Chemical and BDH Sigma. All solutions were prepared using distilled water, and Pyrex glassware was used all along.

- **Camel milk:** Freezing samples were transferred in ice tank from Daro – Aswan – Egypt.
- **Cow milk:** The whole fresh cow's milk was provided by Animal Production Department's herd at Minia University's Faculty of Agriculture

1-2- Carrageenan: - were obtained from local market**.**

1-3- **Microbial Cultures**

- ***Lactobacillus delbrueckii* subsp. *bulgaricus* (EMCC 11102)**
- ***Streptococcus thermophiles* (EMCC 11044)**

were obtained from Cairo Microbiological Resource's Center (MIRCEN) faculty of Agriculture, Ain Shams University.

Manufacture of Yoghurt:

Yoghurt was manufactured as described by **Tamime & Robinson; (1999)**. Yoghurt treatments were prepared as follows:

- ❒ Cow milk as a control (C)
- ❒ Cow milk with 1% Carrageenan (T_1)
- ❒ Cow milk with 1.5% Carrageenan (T_3)
- ❒ Camel milk as a control (C+)
- ❒ Camel milk with 1% Carrageenan (T_2)
- ❒ Camel milk with 1.5% Carrageenan (T_4)

The supplemented cow milk had been heated to 85℃ for 15 min, but Camel milk had been heated to 65 ℃ for 10 min, cooled to 42 ± 1 ℃ . Inoculated with 2% of starter culture, filled in plastic caps and incubated at 42 ℃ until a uniform coagulation has been obtained. The Yoghurt samples had been kept at 4 ℃ ±1 ℃, and analysed when fresh, 3, 5, and 7 days of manufacturing. The results obtained in this study are the average of three replicates.

Chemical analysis: -

1. **pH, titratable acidity, and total solids**: were determined according to the method described in **AOAC (2023)**.
2. **Determination of total protein:**

   Total nitrogen was determined by Kjeldahl methods as described in **AOAC (2023)** and multiplied by factor 6.38.
3. **Fat content:**

   Fat content of milk and Yoghurt samples were determined as described in **AOAC (2023).**
4. **Determination of acetaldehyde:**

   Acetaldehyde content was determined as described by **Yılmaz, (2006)** and expressed as ppm.

Where:

$$A = \frac{44 \times N \times V}{M} \times 100$$

A = Acetaldehyde amount (ppm).

V = Volume of iodine solution (0.005N) used during titration. (mL).

N = Normality of used iodine solution in titration.

M = Sample weight (gram).

5- Determination of Diacetyl and Acetoin:

Diacetyl and acetoin were determined using the standard solutions of acetoin and diacetyl prepared according to **Westerfeld, (1945).** The results were expressed as optical density (O.D) at 540 nm.

6- Water holding capacity (WHC):

The susceptibility of yoghurt to water holding capacity was determined using the method described by **Keogh & O'Kennedy, (1998),** with the following modifications 45 g of yoghurts (Y) in 50 ml conical plastic tubes (falcon type) were centrifuged at 3000 g for 20 min at 4°C. The clear supernatant (W) was poured off, weighed and the water-holding capacity (WHC/ 100g) was calculated as:

$$WHC = (Y - W)/Y \times 100.$$

Where:

Y= 45 g of yoghurt

W= The clear supernatant

7- Measurement of syneresis:

Yoghurt syneresis (the release of whey) was determined by the centrifugation method described by **Keogh & O'Kennedy, (1998).** Yoghurt (20g) was centrifuged (at 640g, 20min, 4˚C) and the clear supernatant was harvested and weighed. Syneresis was calculated according to the following equation:

$$\text{Syneresis (\%)} = \frac{\text{weight of supernatant (g)}}{\text{Weight of Yoghurt sample (g)}} \times 100$$

Determination of Antioxidant properties: -

(1) Preparation of Sample extract

Yoghurt was extracted according to **Guzmán-Ortiz et al., (2017); Leksono et al., (2022)**.

(2) Radical Scavenging method (DPPH): was determined according to the method described by **Al-Saleh et al., (2014); Leksano *et al*., (2022)**. The DPPH radical scavenging activity was calculated using the following equation:

$$\% \text{ DPPH scavenging activity} = 1 - \frac{\text{sample absorbance at 517mm}}{\text{control absorbance at 517 nm}} \times 100$$

(3) Determination Vitamin C:

Ascorbic acid content in Yoghurt was determined according to **AOAC Method 967.21 (2016)**

The vitamin C content was expressed as mg/100g using the following equations:

$$F/ml = \frac{2ml}{V - B} /2$$

where:

- F = mg ascorbic acid / mL.
- 2 ml= Volume of standard ascorbic acid used in titration.
- V = volume of dye used to titrate standard.
- B= volume of dye used to titrate blank.
- 2= to obtained of mg ascorbic acid / ml.

$$\text{mg ascorbic acid}/g = \frac{(V - B) \times F}{w}$$

where:

- V= volume of dye used to titrate sample.
- B= volume of dye used to titrate blank.
- F= mg ascorbic acid / ml.
- W= weight of sample (0.2 g/ 2 ml used in titration in this test).

Bacterial counts

Lactic acid bacterial counts were determined using MRS agar media as described by **(Ismaiel *et al*., 2018; Zahrani & Shori, 2023).** and the viability of bacteria was calculated as follows:

$$\log cfu/ml = \log \left(\frac{\text{Number of colonies} \times \text{dilution factor}}{\text{valume of sample in Plate (1ml)}}\right)$$

Sensory Evaluation

Sensory evaluation of yoghurt samples was measured with nine hedonic scale as described by **(Degbeu *et al*., 2023; Ali *et al*., 2024)**. As follows:

1-dislike extremely, 2-dislike very much, 3-dislike moderately, 4-dislike slightly, 5-neutral, 6-like slightly, 7-like moderately, 8-like very much, and 9-like extremely.

Statistical analysis

Data collected were subjected to two-way Analysis of Variance (ANOVA). The differences were separated using the Least Significant Difference (LSD) **(Motulsky, 1999).**

RESULTS AND DISCUSSION:

Gross composition of fresh milk and camel milk yoghurt and cow milk yoghurt (Control) were analyzed for nutrients and pH as shown in Table (1). Compared to composition of fresh cow milk, camel milk had low protein, fat, total solids, pH and had high moisture (3.0%, 3.2%, 12.46%, 6,51% and 87.54%) respectively. The results obtained in this study agreed with the findings of **Sulieman *et al*., (2006), Eissa *et al*., (2011).**

Nutrients Composition of Camel and Cow milk was affected by processing yoghurt. Also, Carmel milk was richer in vitamin (C) (37mg/L) and had higher antioxidant activity (42.693 %) compared to cow's milk (14mg/L and 35.33 %) respectively.

Additionally, camel milk Contained higher total flavonoids (95.38 mg/100ml), total phenolic content (27.96mg/100 ml) than Cow milk

Table (1): The Chemical Compositions of Raw Cow and Camel's milk.

Variables	Camel Milk	Cow Milk
pH	6.51	6.66
Acidity	0.17	0.18
Moisture	87.54 %	86.33 %
Total Solid	12.46 %	13.67 %
Fat	3.0 %	3.1 %
Protein	3.2 %	3.4 %
Vitamin C	37 mg / L	14 mg / L
Antioxidant	42.693 %	35.33 %
Total Flavonoid	95.38462 mg / 100 ml	69.23077 mg / 100 ml
Total Phenolic Content	27.95918367 mg / 100 ml	24.06307978 mg / 100 ml

Effect of Storage on Composition, pH and acidity of yoghurt

Table (2) revealed the changes in composition of yoghurt made from camel and cow milk during storage at 4℃ ± 1 for different periods of time (Fresh, 3, 5 and 7 days). The results obtained showed that the total solids increased significantly (P< 0.05) during storage in all treatments.

Also, Table (2) showed that cow milk yoghurts Consistently had higher total solids than Camel milk yoghurts. During storage the moisture Content of cow and camel milk yoghurt decreased Significantly (P<0.05).

Changes in pH and acidity of cow and camel milk yoghurt were shown in Table (3) and Fig (1a, 1b, 2a and 2b).

Cow and camel milk yoghurt had pH values of 4.57 and 4.57, Coupled with acidity of 0.567% and 0.552'%. respectively (Fig: 2a,2b). Addition of carrageenan to cow and camel milk yoghurt significantly

(P< 0.05) affected pH and acidity values and for all fresh Samples as shown in Table (3). After 7 days of storage at 4 C ± 1 the acidity in cow milk yoghurt treatments with carrageenan was significantly higher (P<0.05) than that of camel milk yoghurt treatments.

During storge a slower acidification in camel milk yoghurt was found. This may be attributed to the presence of antimicrobial agents in the camel milk **(Elagamy, 2000).** The addition of Carrageenan caused the highest acidity and the lowest pH of Camel milk yoghurt compared with those which did not have stabilizer (C and C^{+}), The results are Similar with those by **Ibrahim & Khalifa ، (2015).**

Water Holding Capacity (WHC) and Syneresis:

WIHC increased while syneresis decreased over storge in all samples. Cow milk Yoghurt with Carrageenan reached 100% WHC and zero Syneresis on first day, while camel's milk required carrageenan to achieve Similar stability. Camel milk yoghurt treatments (T_1, T_3 and T_4) with carrageenan (1%) exhibited the lowest WHC these results are in good agreement with what have been found by **Ibrahim & Khalifa., (2015); Kamal-Eldin *et al*; (2020).**

The higher concentration of carrageenan (1.5%), could have immobilized the aqueous phase of camel milk yoghurt **(Galeboe *et al*., 2018; Mudgil *et al*, 2018).**

The water mobility within the stabilizers during storage leads to lower syneresis. Carrageenan helped to improve the water holding capacity of the curd by preventing the undesirable separation of whey. (Syneresis) during storage and maintained a consistent texture **(Kalsi *et al*., 2025).**

The addition of Carrageenan to fermented camel milk enhanced curd firmness and improved yoghurt's texture by stabilizing the protein network, camel milk lacks the proper casein structure and has high levels of whey protein and antimicrobial components that hinder natural gel fermentation, making it difficult to achieve a firm curd. Carrageenan works as stabilizer by strengthening the gel structure preventing syneresis; and improving the overall consistency of the fermented product **(Murtaza et al., 2025).**

Flavor components (Carbonyl Compounds):

The addition of carrageenan at different concentration to cow or camel milk for yoghurt manufacture, significantly ($P<0.05$) influenced the formation of acetaldehyde, which is considered the primary volatile compound responsible for the characteristic yoghurt flavour **(cardoso *et al*., 2025).**

As shown in Table (5) there are significant ($P< 0.05$) differences in acetaldehyde contents between control yoghurt (C and C^+) and treatments with carrageenan (T_1, T_2, T_3 and T_4). In camel milk yoghurt, carrageenan supplementation led to a noticeable increase in acetaldehyde content on the first day of production. During Storage at 4℃ ± 1 acetaldehyde content gradually increased in all treatments till the 7th day.

Table (2): Changes in Total Solids (%) of Yoghurt Samples without Carrageenan during Strong at 4℃ for 7 days.

Storage Period (Days) \ Treatment	Cow Milk (Control)	Camel Milk (Control +)
1st	12.207321^{e} ± 0.070	8.1392^{l} ± 0.011
3	13.5577^{d} ±0.004	9.2854^{k} ± 0.037
5	14.1717^{c}± 0.030	10.5106^{h} ± 0.174
7	15.7696^{a} ± 0.034	12.2469^{e} ± 0.005

Table (3): Changes in pH and Titratable acidity of Yoghurt Samples during Strong at 4℃ for 7 days.

Storage Period (Days) \ Treatment	Cow Milk (Control)		Cow Milk + 1 % (T_1)		Cow Milk +1.5 % (T_3)	
	pH	T.A (%)	pH	T.A (%)	pH	T.A (%)
1st	4.57 ^{a} ± 0.01	0.567^{s} ±0.001	4.43^{e} ± 0.01	0.582^{q} ±0.001	4.39^{h} ± 0.01	0.613^{n} ±0.001
3	4.49^{d} ± 0.01	0.603^{o} ±0.001	4.29^{j} ± 0.01	0.682^{j} ±0.001	4.24^{l} ± 0.01	0.703^{h} ±0.001
5	4.42^{ef} ± 0.01	0.632^{l} ±0.001	4.16^{m} ± 0.01	0.772^{f} ±0.001	4.09^{n} ± 0.01	0.783^{e} ±0.001
7	4.29^{j} ± 0.01	0.692^{i} ±0.001	4.04^{o} ± 0.01	0.822^{b} ±0.001	3.97^{p} ± 0.01	0.913^{a} ±0.001
Storage Period (Days) \ Treatment	**Camel Milk (Control +)**		**Camel Milk +1 % (T_2)**		**Camel Milk + 1.5 % (T_4)**	
	pH	T.A (%)	pH	T.A (%)	pH	T.A (%)
1st	4.57^{b} ± 0.01	0.552^{t}±0.001	4.50^{c} ± 0.01	0.572^{r} ±0.001	4.47^{d} ± 0.01	0.583^{q} ±0.001
3	4.49^{c} ± 0.01	0.592^{p} ±0.001	4.42^{fg} ± 0.01	0.622^{m} ±0.001	4.30^{j} ± 0.01	0.683^{j} ±0.001
5	4.41^{gh} ± 0.01	0.642^{k} ±0.001	4.29^{j} ± 0.01	0.703^{h} ±0.001	4.17^{m} ± 0.01	0.753^{g} ±0.001
7	4.34^{i} ± 0.01	0.682^{j} ±0.001	4.10^{n} ± 0.01	0.793^{d} ±0.001	4.04^{o} ± 0.01	0.803^{c} ±0.001

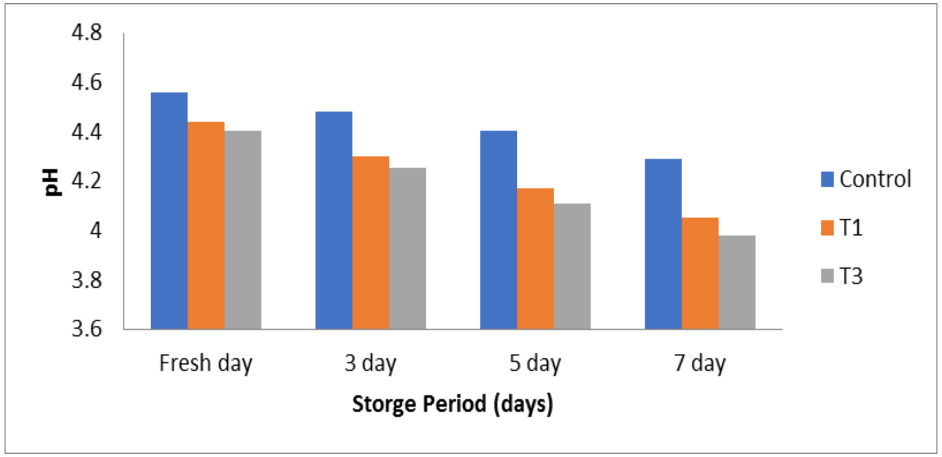


Fig (1a): Changes in pH of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

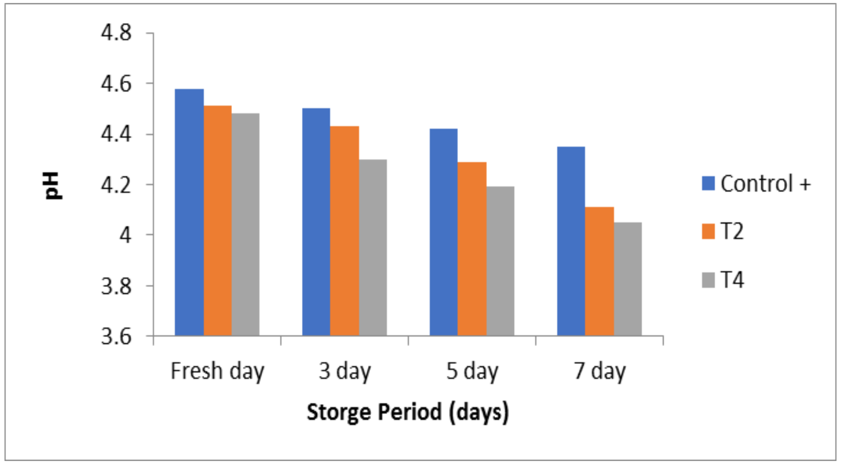


Fig (1b): Changes in pH of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

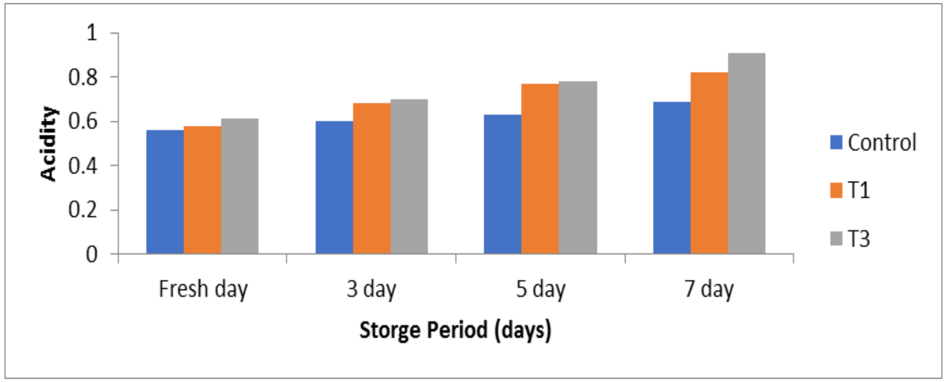


Fig (2a): Changes in Titratable acidity of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

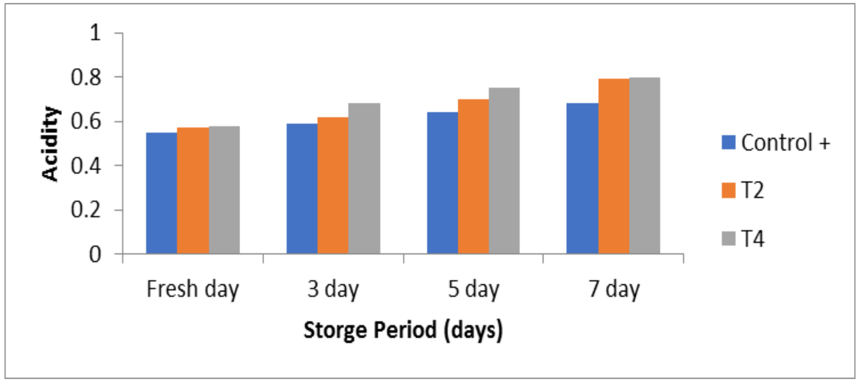


Fig (2b): Changes in Titratable acidity of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

Table (4): Changes in Water Holding Capacity (W.H.C) and Syneresis of Yoghurt Samples during Strong at 4℃ for 7 days.

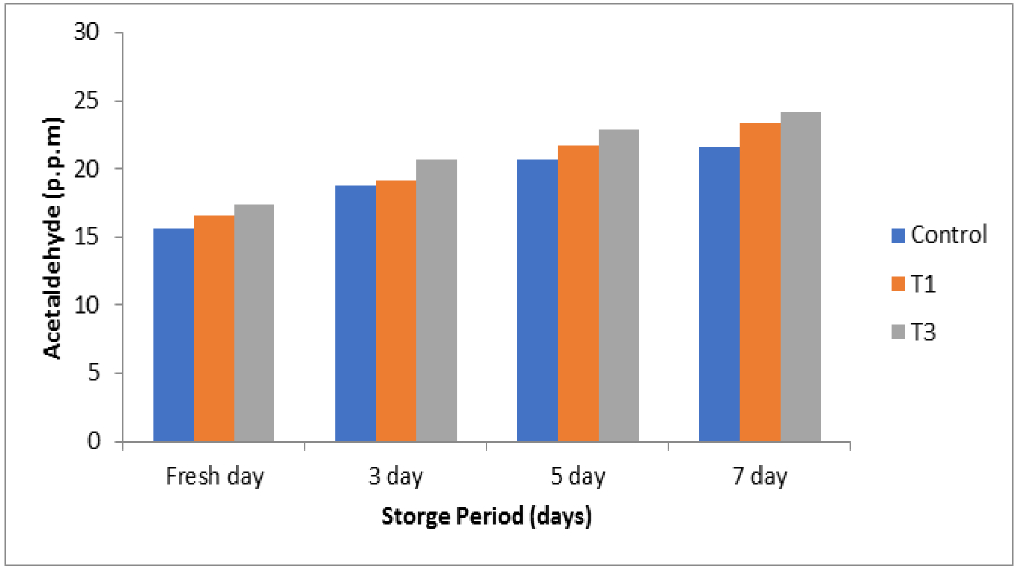
Treatment / Storage Period (Days)	Cow Milk (Control)		Cow Milk + 1 % (T_1)		Cow Milk +1.5 % (T_3)	
	W.H.C (%)	Syneresis (%)	W.H.C (%)	Syneresis (%)	W.H.C (%)	Syneresis (%)
1st	$54.782685^{f} \pm 0.0397$	$45.8649^{q} \pm 0.02145$	100^{a}	0^{z}	100^{a}	0^{z}
3	$55.8151^{e} \pm 0.00575$	$44.1964^{t} \pm 0.00575$	100^{a}	0^{z}	100^{a}	0^{z}
5	$57.8211^{d} \pm 0.00505$	$42.189^{u} \pm 0.00505$	100^{a}	0^{z}	100^{a}	0^{z}
7	$59.8315^{c} \pm 0.0155$	$40.1995^{v} \pm 0.0155$	100^{a}	0^{z}	100^{a}	0^{z}

Treatment / Storage Period (Days)	Camel Milk (Control +)		Camel Milk +1 % (T_2)		Camel Milk + 1.5 % (T_4)	
	W.H.C (%)	Syneresis (%)	W.H.C (%)	Syneresis (%)	W.H.C (%)	Syneresis (%)
1st	$17.8953^{t} \pm 0.14495$	$82.3946^{a} \pm 0.14495$	$34.771261^{p} \pm 0.0273$	$65.2776^{h} \pm 0.01225$	100^{a}	0^{z}
3	$33.7921^{q} \pm 0.0863$	$66.3805^{b} \pm 0.0863$	$50.8694^{i} \pm 0.00505$	$49.1407^{p} \pm 0.00505$	100^{a}	0^{z}
5	$41.9257^{m} \pm 0.1514$	$58.3771^{j} \pm 0.1514$	$64.6699^{c} \pm 0.0042$	$35.3385^{x} \pm 0.0042$	100^{a}	0^{z}
7	$49.79234^{j} \pm 0.07829$	$50.36424^{m} \pm 0.07829$	$77.8676^{b} \pm 0.0039$	$22.1324^{y} \pm 0.0039$	100^{a}	0^{z}

Table (5): Concentration of Flavor components in Yoghurt Samples during Strong at 4℃ for 7 days.

Treatment / Storage Period (Days)	Cow Milk (Control)			Cow Milk + 1 % (T_1)			Cow Milk +1.5 % (T_3)		
	Acetaldehyde (p.p.m)	Diacetyl (O.D.) at 540 nm	Acetoin (O.D.) at 540 nm	Acetaldehyde (p.p.m)	Diacetyl (O.D.) at 540 nm	Acetoin (O.D.) at 540 nm	Acetaldehyde (p.p.m)	Diacetyl (O.D.) at 540 nm	Acetoin (O.D.) at 540 nm
1st	$15.68^{x} \pm 0.02$	$0.128^{q} \pm 0.006$	$0.1605^{t} \pm 0.003$	$16.51^{w} \pm 0.02$	$0.1625^{o} \pm 0.003$	$0.2025^{o} \pm 0.001$	$17.41^{v} \pm 0.02$	$0.193^{m} \pm 0.002$	$0.235^{n} \pm 0.001$
3	$18.83^{s} \pm 0.02$	$0.138^{p} \pm 0.001$	$0.178^{s} \pm 0.002$	$19.16^{r} \pm 0.02$	$0.2095^{k} \pm 0.003$	$0.268^{l} \pm 0.001$	$20.62^{n} \pm 0.02$	$0.237^{i} \pm 0.004$	$0.299^{i} \pm 0.004$
5	$20.66^{m} \pm 0.02$	$0.1605^{o} \pm 0.001$	$0.2025^{o} \pm 0.005$	$21.65^{j} \pm 0.02$	$0.2525^{f} \pm 0.005$	$0.321^{g} \pm 0.004$	$22.87^{g} \pm 0.02$	$0.277^{e} \pm 0.002$	$0.367^{e} \pm 0.004$
7	$21.65^{j} \pm 0.02$	$0.1755^{n} \pm 0.001$	$0.2235^{n} \pm 0.003$	$23.325^{e} \pm 0.01$	$0.287^{c} \pm 0.004$	$0.365^{e} \pm 0.004$	$24.225^{b} \pm 0.01$	$0.312^{b} \pm 0.002$	$0.417^{b} \pm 0.003$

Treatment / Storage Period (Days)	Camel Milk (Control +)			Camel Milk +1 % (T_2)			Camel Milk + 1.5 % (T_4)		
	Acetaldehyde (p.p.m)	Diacetyl (O.D.) at 540 nm	Acetoin (O.D.) at 540 nm	Acetaldehyde (p.p.m)	Diacetyl (O.D.) at 540 nm	Acetoin (O.D.) at 540 nm	Acetaldehyde (p.p.m)	Diacetyl (O.D.) at 540 nm	Acetoin (O.D.) at 540 nm
1st	$17.66^{u} \pm 0.02$	$0.2165^{j} \pm 0.003$	$0.184^{r} \pm 0.002$	$18.595^{t} \pm 0.01$	$0.207^{l} \pm 0.004$	$0.28^{k} \pm 0.002$	$19.97^{p} \pm 0.04$	$0.2325^{i} \pm 0.001$	$0.3125^{h} \pm 0.001$
3	$19.965^{q} \pm 0.01$	$0.237^{i} \pm 0.004$	$0.2235^{n} \pm 0.002$	$20.14^{o} \pm 0.02$	$0.2455^{h} \pm 0.001$	$0.339^{f} \pm 0.006$	$21.515^{k} \pm 0.01$	$0.275^{e} \pm 0.002$	$0.378^{d} \pm 0.002$
5	$21.14^{l} \pm 0.02$	$0.261^{f} \pm 0.004$	$0.2455^{m} \pm 0.003$	$22.38^{h} \pm 0.02$	$0.285^{c} \pm 0.004$	$0.374^{d} \pm 0.002$	$23.76^{d} \pm 0.02$	$0.317^{b} \pm 0.004$	$0.422^{b} \pm 0.006$
7	$23.15^{f} \pm 0.02$	$0.287^{c} \pm 0.004$	$0.3005^{i} \pm 0.001$	$24.16^{c} \pm 0.02$	$0.317^{b} \pm 0.004$	$0.42^{b} \pm 0.002$	$25.52^{a} \pm 0.02$	$0.3455^{a} \pm 0.003$	$0.4595^{a} \pm 0.003$



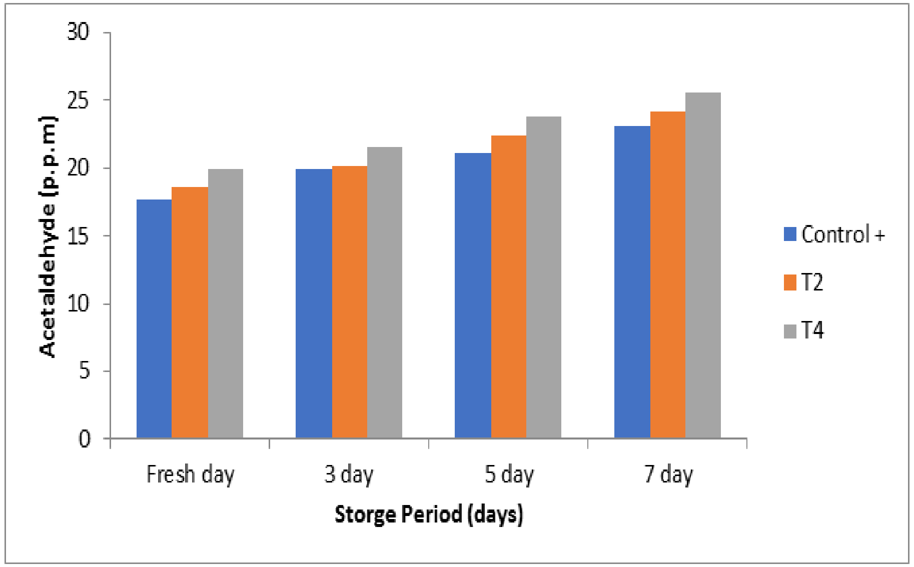


Fig (3a): Changes in Acetaldehyde of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

Fig (3b): Changes in Acetaldehyde of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

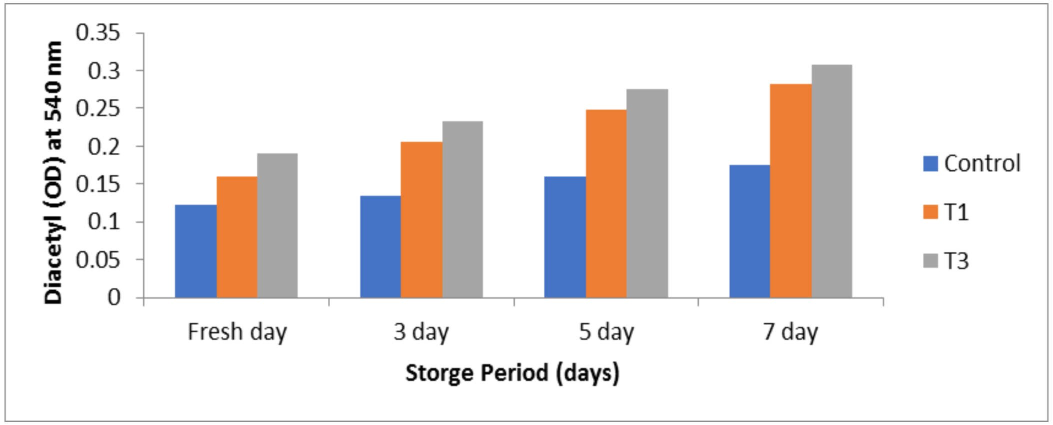


Fig (4a): Changes in Diacetyl of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

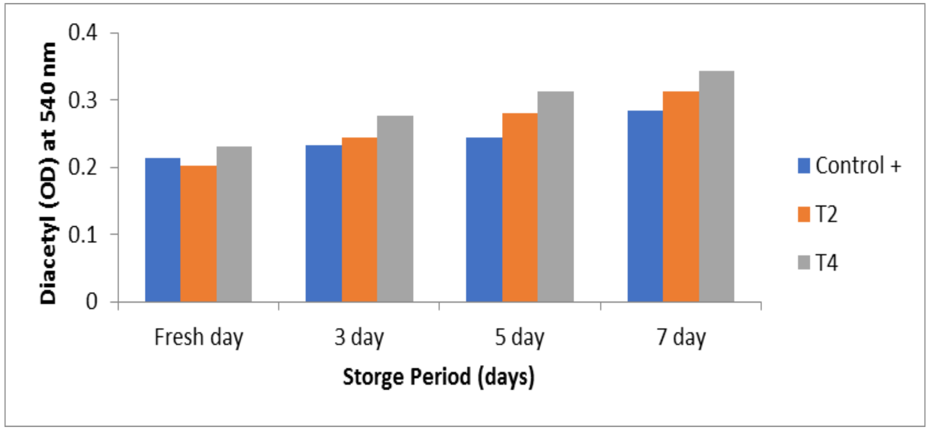


Fig (4b): Changes in Diacetyl of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

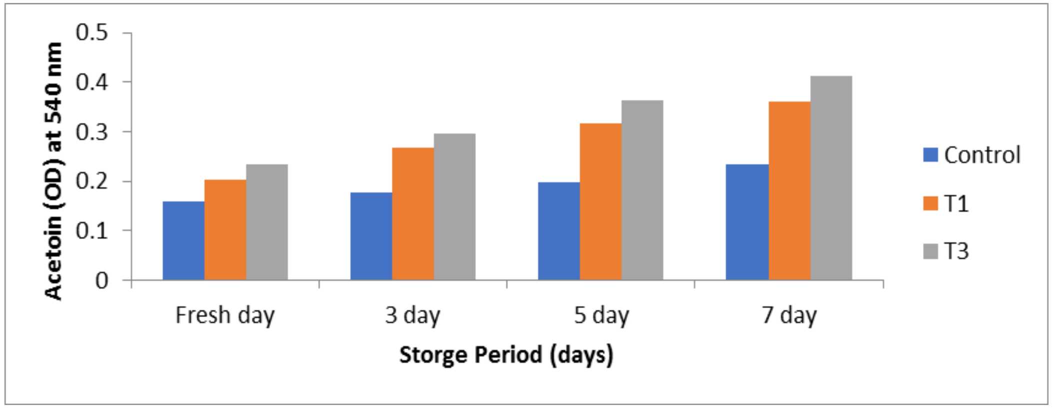


Fig (5a): Changes in Acetoin of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

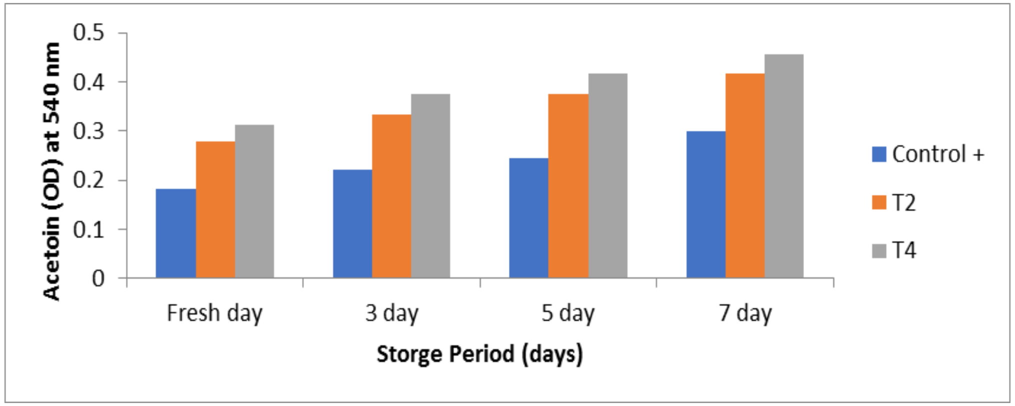


Fig (5b): Changes in Acetoin of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

The highest value of acetaldehyde Content has been recorded by control (T4) (25.52 ppm). However, the lowest value was noticed by Control (C) (21.65 ppm) after 7 days of storage.

Results in Table (5) and Fig (4a, 4b, 5a and 5b) showed the concentration of diacetyl, and acetoin as (O. D. at 540 mm) contents. Acetaldehyde behaved as a similar manner either when fresh or during storge. Higher carbonyl compounds level could be due to the interaction between carrageenan and the starter culture bacteria, which may have promoted their metabolic activity and flavored synthesis compounds. This finding highlights the potential role of carrageenan not only as a texturizing and stabilizing agent but also as a functional ingredient capable of improving the sensory quality of yoghurt, particularly that made from camel milk, these results are in agreement with those obtained by Oselu et al., (2022; Edo et al., (2025).

Vitamin C and Antioxidant activity (DPPH):

Camel milk yoghurt contained significantly higher level of Vitamin (C) and DPPH activity than cow milk yoghurts. Both parameters increased during storage. Camel milk itself contains higher levels of certain vitamins, including vitamin (C), compared to cow milk, providing a more nutritional foundation for yoghurts. Metwalli & Hailu (2020) mentioned that camel milk has more 4 – 6 times vitamin C than cow milk. Camel milk yoghurt exhibited DPPH activity more than cow milk yoghurt when fresh and during storage. The highest DPPH was recorded with T4 (102.015) and the lowest with (C) (43.723) during storage. for 7 days at 4°C ± 1. These results are in agreement with El-Deeb et al., (2017) and Abou- Soliman et at., (2025).

Camel milk yoghurt with carrageenan had higher vitamin (C) Content and DPPH activity compared to the cow milk yoghurt. A similar finding was reported by El-Deeb et al., (2017).

The higher Vitamin (C) Content and DPPH activity in Camel milk yoghurts contribute to their potential health benefits, such as improved antioxidant activity (Stobiecka et al., 2022).

Viability of bacteria

Total viable counts of starter bacteria had been determined at the end of acidification and during 7 days storage at 4°C ± 1. Viable counts of starter bacteria (>log 107 cfu/ml) throughout storage period had slight decrease during the first days then started to be stable. The high viability ensures that the product contains sufficient live organisms in addition to provide the expended health benefits of Lactic acid bacteria.

Table (7) show the total numbers of (LAB). It turns out that the counts of LAB increased ($P<0.05$) significantly by adding Carrageenan.

Sensory Evolution

Sensory scores for overall acceptability, consistency, odor, taste, colour, and appearance were generally higher in cow milk yoghurts compared to camel milk yoghurts.

Addition carrageenan improved texture and acceptability, particularly in camel milk samples. The highest scores recorded for cow milk yoghurt with 1% Carrageenan (44.28), while camel milk yoghurt with 1.5% carrageenan (39.6) showed the best performance among camel milk treatments.

Adel et al., (2011) found that scores of tastes, colour, texture, flavour and overall preference of camel milk were significantly ($P< 0.05$) lower than those of cow milk. But the low organoleptic attributes of camel milk yoghurt Samples could be associated with several factors involving elevated levels of polyunsaturated fatty acids, high contraction of salts (in particular chlorides), high whey protein and low contains of casein.

Sensory evolution of fermented camel milk, with carrageenan focuses on its desirable sensory attributes, such as body, texture and colour to enhance its market appeal.

On the other hand, there was no mold or yeast growth detected on the yogurt surface during storage for all treatments.

This could possibly be the result of the sanitary conditions in which the manufacturing processes were conducted, or it could be the function of lactic acid bacteria in product preservation, which is linked to their capacity to create certain antimicrobial chemicals. Similar results have been reported by Salma, (2019) and AL-Sagher, (2022).

CONCLUSION:

Camel milk yoghurt generally exhibits lower pH, higher acidity and weaker curd firmness compared to cow milk yoghurt.

However, the addition of carrageenan effectively improved the gel strength and reduced syneresis. Carrageenan also increased the carbonyl compounds level and antioxidant activity as DPPH and vitamin (C). The optimal level of carrageenan was found to be 1.5 % which provided a smooth, firm and stable yoghurt structure.

Table (6): Changes in DPPH activity and Vitamin C concentration of Yoghurt Samples during Strong at 4℃ for 7 days.

Treatment / Storage Period (Days)	Cow Milk (Control)		Cow Milk + 1 % (T_1)		Cow Milk +1.5 % (T_3)	
	DPPH % Scavenging activity	Vitamin C (mg / L)	DPPH % Scavenging activity	Vitamin C (mg / L)	DPPH % Scavenging activity	Vitamin C (mg / L)
1st	$43.723^{x} \pm 0.001$	$19.27^{w} \pm 0.01$	$57.793^{u} \pm 0.001$	$21.73^{u} \pm 0.01$	$63.656^{r} \pm 0.001$	$25.07^{r} \pm 0.01$
3	$49.083^{w} \pm 0.001$	$20.8^{v} \pm 0.01$	$65.666^{p} \pm 0.001$	$23.27^{t} \pm 0.01$	$70.021^{n} \pm 0.001$	$26.6^{o} \pm 0.01$
5	$58.463^{t} \pm 0.001$	$23.47^{s} \pm 0.01$	$77.056^{j} \pm 0.001$	$25.73^{q} \pm 0.01$	$75.716^{l} \pm 0.001$	$29.73^{m} \pm 0.01$
7	$63.991^{q} \pm 0.001$	$26.4^{p} \pm 0.01$	$82.752^{g} \pm 0.001$	$28.73^{n} \pm 0.01$	$83.757^{f} \pm 0.001$	$32.6^{l} \pm 0.01$

Treatment / Storage Period (Days)	Camel Milk (Control +)		Camel Milk + 1 % (T_2)		Camel Milk + 1.5 % (T_4)	
	DPPH % Scavenging activity	Vitamin C (mg / L)	DPPH % Scavenging activity	Vitamin C (mg / L)	DPPH % Scavenging activity	Vitamin C (mg / L)
1st	$56.118^{v} \pm 0.001$	$41.52^{k} \pm 0.01$	$73.539^{m} \pm 0.001$	$42.24^{j} \pm 0.01$	$80.574^{i} \pm 0.001$	$43.19^{g} \pm 0.01$
3	$62.149^{q} \pm 0.001$	$42.24^{j} \pm 0.01$	$80.909^{h} \pm 0.001$	$42.57^{i} \pm 0.01$	$86.437^{d} \pm 0.001$	$43.44^{e} \pm 0.01$
5	$67.844^{o} \pm 0.001$	$43.04^{h} \pm 0.01$	$85.934^{e} \pm 0.001$	$43.34^{f} \pm 0.01$	$93.304^{c} \pm 0.001$	$44.13^{b} \pm 0.01$
7	$76.889^{k} \pm 0.001$	$43.83^{d} \pm 0.01$	$94.309^{b} \pm 0.001$	$44.03^{c} \pm 0.01$	$102.015^{a} \pm 0.001$	$44.73^{a} \pm 0.01$

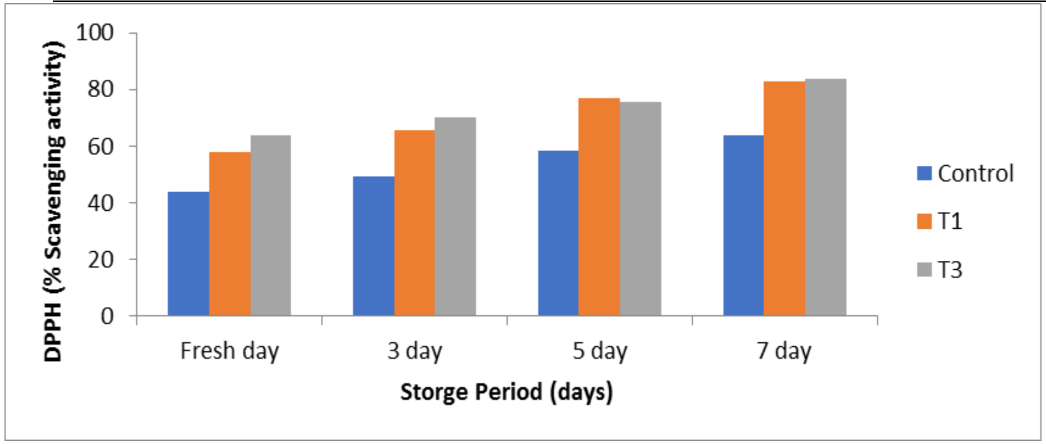


Fig (6a): Changes in DPPH of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

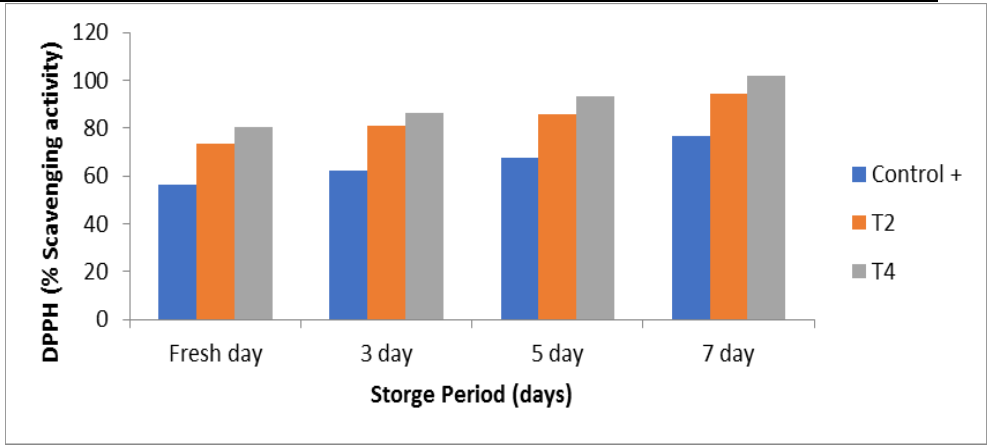


Fig (6b): Changes in DPPH of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

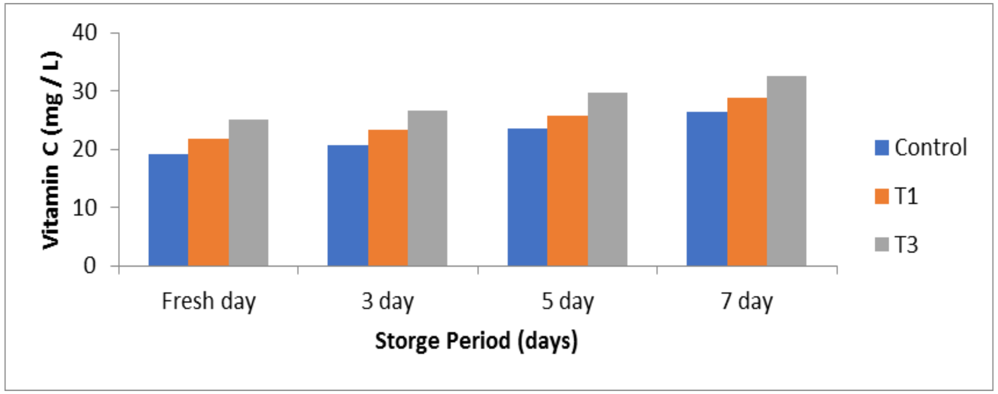


Fig (7a): Changes in Vitamin C of cow milk yoghurt Samples during Strong at 4℃ for 7 days.

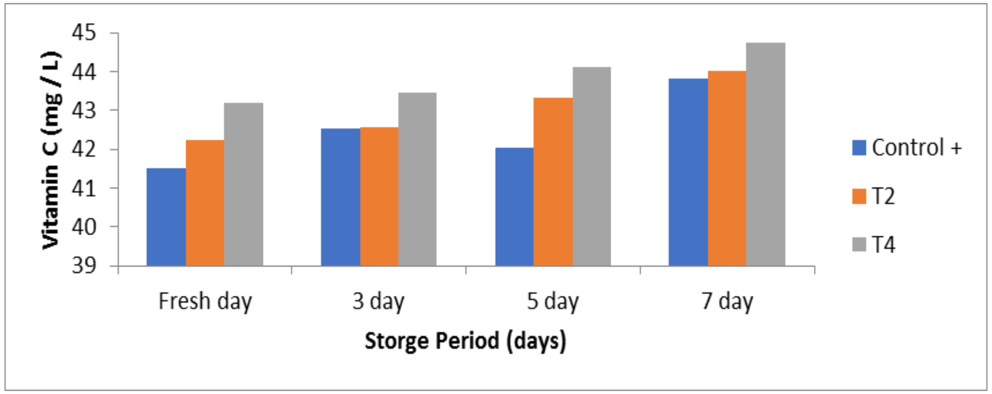


Fig (7b): Changes in Vitamin C of camel milk yoghurt Samples during Strong at 4℃ for 7 days.

Table (7): Changes of Viable Lactic acid Bacteria (*Lactobacillus delbrueckii subsp. bulgaricus*) during Strong at 4℃ for 7 days.

Treatment / Storage Period (Days)	Cow Milk (Control) Log (cfu. / ml)	Cow Milk + 1 % (T_1) Log (cfu. / ml)	Cow Milk +1.5 % (T_3) Log (cfu. / ml)
1st	$9.122^{q} \pm 0.001$	$9.135^{p} \pm 0.002$	$9.194^{o} \pm 0.002$
3	$9.195^{o} \pm 0.002$	$9.274^{k} \pm 0.002$	$9.314^{j} \pm 0.002$
5	$9.35^{h} \pm 0.005$	$9.45^{e} \pm 0.01$	$9.484^{c} \pm 0.002$
7	$9.46^{d} \pm 0.005$	$9.557^{a} \pm 0.003$	$9.545^{b} \pm 0.002$

Treatment / Storage Period (Days)	Camel Milk (Control +) Log (cfu. / ml)	Camel Milk + 1 % (T_2) Log (cfu. / ml)	Camel Milk + 1.5 % (T_4) Log (cfu. / ml)
1st	$8.915^{v} \pm 0.002$	$8.914^{v} \pm 0.002$	$8.974^{u} \pm 0.002$
3	$9.06^{s} \pm 0.01$	$9.064^{st} \pm 0.003$	$9.11^{r} \pm 0.002$
5	$9.24^{m} \pm 0.01$	$9.254^{l} \pm 0.003$	$9.274^{k} \pm 0.002$
7	$9.33^{i} \pm 0.01$	$9.374^{g} \pm 0.002$	$9.412^{f} \pm 0.001$

Table (8): Changes in Sensory properties of Cow milk Yoghurt Samples during Strong at 4℃ for 7 days.

Treatments	Storage Period Days	Variables (Sensory Properties)					
		Appearance	Color	Taste	Odor	Consistency	Overall acceptability
Cow Milk (Control)	1st	$8.91^{ab} \pm 0.05$	$8.46^{c} \pm 0.05$	$8.46^{abc} \pm 0.05$	$8.82^{ab} \pm 0.05$	$7.92^{b} \pm 0.9$	$41.4^{cde} \pm 0.9$
	3	$9.17^{a} \pm 0.05$	$8.46^{c} \pm 0.05$	$8.46^{abc} \pm 0.05$	$8.82^{ab} \pm 0.05$	$7.92^{b} \pm 0.9$	$41.4^{cde} \pm 0.9$
	5	$9^{a} \pm 0.01$	$8.46^{c} \pm 0.05$	$8.28^{ac} \pm 0.05$	$8.64^{ac} \pm 0.05$	$7.92^{b} \pm 0.9$	$40.5^{def} \pm 0.9$
	7	$9^{a} \pm 0.01$	$8.46^{c} \pm 0.05$	$7.74^{bc} \pm 0.05$	$8.46^{abc} \pm 0.05$	$7.92^{b} \pm 0.9$	$40.5^{def} \pm 0.9$
Cow Milk + 1 % (T_1)	1st	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$8.28^{a} \pm 0.05$	$44.28^{a} \pm 0.9$
	3	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$8.28^{a} \pm 0.05$	$44.28^{a} \pm 0.9$
	5	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$8.46^{abc} \pm 0.01$	$9^{a} \pm 0.01$	$8.28^{a} \pm 0.05$	$43.74^{ab} \pm 0.9$
	7	$9^{a} \pm 0.01$	$9^{a} \pm 0.01$	$7.92^{b} \pm 0.05$	$8.64^{ac} \pm 0.05$	$8.28^{a} \pm 0.05$	$42.84^{bcd} \pm 0.9$
Cow Milk +1.5 % (T_3)	1st	$8.83^{ab} \pm 0.03$	$8.28^{d} \pm 0.03$	$8.64^{ab} \pm 0.05$	$8.64^{ac} \pm 0.05$	$7.92^{b} \pm 0.9$	$41.04^{cde} \pm 0.9$
	3	$8.83^{ab} \pm 0.03$	$8.28^{d} \pm 0.03$	$8.64^{ab} \pm 0.05$	$8.64^{ac} \pm 0.05$	$7.92^{b} \pm 0.9$	$41.04^{cde} \pm 0.9$
	5	$8.83^{ab} \pm 0.03$	$8.28^{d} \pm 0.03$	$8.64^{ab} \pm 0.05$	$8.46^{abc} \pm 0.05$	$7.92^{b} \pm 0.9$	$40.86^{def} \pm 0.9$
	7	$8.83^{ab} \pm 0.03$	$8.28^{d} \pm 0.03$	$8.64^{ab} \pm 0.05$	$8.28^{ad} \pm 0.05$	$7.92^{b} \pm 0.9$	$40.32^{def} \pm 0.9$

Table (9): Changes in Sensory properties of Camel milk Yoghurt Samples during Strong at 4℃ for 7 days.

Treatments	Storage Period Days	Variables (Sensory Properties)					
		Appearance	Color	Taste	Odor	Consistency	Overall acceptability
Camel Milk (Control +)	1st	$5.4^{c} \pm 0.05$	$8.46^{c} \pm 0.05$	$8.64^{ab} \pm 0.05$	$7.02^{d} \pm 0.05$	$2.52^{d} \pm 0.9$	$28.62^{mn} \pm 0.9$
	3	$5.4^{c} \pm 0.05$	$8.46^{c} \pm 0.05$	$5.58^{e} \pm 0.9$	$7.02^{d} \pm 0.05$	$2.52^{d} \pm 0.9$	$28.62^{mn} \pm 0.9$
	5	$5.4^{c} \pm 0.05$	$8.64^{b} \pm 0.05$	$5.58^{e} \pm 0.9$	$7.02^{d} \pm 0.05$	$2.52^{d} \pm 0.9$	$28.44^{mn} \pm 0.9$
	7	$6.27^{bc} \pm 0.05$	$8.64^{b} \pm 0.05$	$5.58^{e} \pm 0.9$	$7.02^{d} \pm 0.05$	$2.52^{d} \pm 0.9$	$28.44^{mn} \pm 0.9$
Camel Milk +1 % (T_2)	1st	$8.01^{ab} \pm 0.05$	$8.46^{c} \pm 0.05$	$6.84^{c} \pm 0.9$	$7.38^{b} \pm 0.05$	$6.48^{cd} \pm 0.9$	$36^{ijk} \pm 0.9$
	3	$8.01^{ab} \pm 0.05$	$8.46^{c} \pm 0.05$	$6.84^{c} \pm 0.9$	$7.38^{b} \pm 0.05$	$6.48^{cd} \pm 0.9$	$36^{ijk} \pm 0.9$
	5	$8.01^{ab} \pm 0.05$	$8.46^{c} \pm 0.05$	$6.48^{de} \pm 0.9$	$7.2^{c} \pm 0.05$	$6.48^{cd} \pm 0.9$	$35.64^{jk} \pm 0.9$
	7	$7.97^{abc} \pm 0.05$	$8.46^{c} \pm 0.05$	$6.3^{cd} \pm 0.9$	$7.2^{c} \pm 0.05$	$6.48^{cd} \pm 0.9$	$35.28^{jk} \pm 0.9$
Camel Milk + 1.5 % (T_4)	1st	$8.83^{ab} \pm 0.03$	$8.64^{b} \pm 0.05$	$6.66^{cd} \pm 0.9$	$8.64^{ac} \pm 0.05$	$8.28^{a} \pm 0.05$	$39.6^{efg} \pm 0.9$
	3	$7.41^{abc} \pm 0.05$	$8.64^{b} \pm 0.05$	$6.66^{cd} \pm 0.9$	$8.64^{ac} \pm 0.05$	$8.28^{a} \pm 0.05$	$39.6^{efg} \pm 0.9$
	5	$7.41^{abc} \pm 0.05$	$8.64^{b} \pm 0.05$	$6.1^{de} \pm 0. 05$	$7.2^{c} \pm 0.05$	$7.02^{bc} \pm 0.9$	$38.34^{efg} \pm 0.9$
	7	$7.41^{abc} \pm 0.05$	$8.64^{b} \pm 0.05$	$6.66^{cd} \pm 0.9$	$7.02^{d} \pm 0.05$	$6.66^{c} \pm 0.9$	$36.36^{hij} \pm 0.9$

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الملخص العربي

تأثير الكاراجينان على الخواص الكيميائية والطبيعية والتركيبية لزبادي لبن الجمل

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الهدف من هذه الدراسة هو دراسة تأثير إضافة مادة الكاراجينان إلى لبن الجمل المعد لصناعة الزبادي مقارنة باللبن البقري. النتائج أوضحت أن الزبادي المصنع من لبن الجمل كان منخفض في قيم الـ pH ومرتفع في الحموضة، وفيتامين (C) ونشاط DPPH وأيضاً مرتفع في نسب مركبات الطعم والنكهة ولكن أظهر انخفاض واضح في قوة الخثرة مقارنة باللبن البقري. إضافة الكاراجينان أدى إلى تحسين صفات الخثرة وقوتها كمادة رابطة وقلل من انفصال الشرش وأيضاً إلى زيادة مركبات النكهة ومضادات الأكسدة وإضافة الكاراجينان أدى إلى تحسين الخواص الحسية للزبادي. العد الكلي لبكتريا حامض اللاكتيك كان خلال فترة التخزين ($>10^7$ cfu/ml) والخواص الحسية لزبادي لبن الجمل مع الكاراجينان. ركز البحث على تعديل الخواص الحسية وخاصة التركيب واللون مم يؤدي إلى تحسين صفاته في السوق.