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Physicochemical, Microbiological, and Sensory Properties of Set-Type Yoghurt Supplemented with Camel Casein Hydrolysate

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Abstract: The microbiological, rheological, and sensory properties of set-type yoghurt were investigated in the presence of camel and cow casein hydrolysates produced by the action of trypsin enzymes. The hydrolysates significantly decreased the fermentation and coagulation time of the yoghurt production. The rate of pH decrease was significantly ($p < 0.05$) higher in samples treated with cow casein hydrolysate in comparison with control samples. Compared with the control, the cell growth of the yoghurt culture increased with the supplementation of the casein hydrolysate. Moreover, the survival of lactic acid bacteria (LAB) was enhanced by the addition of hydrolysates. The fortification of cow milk with camel and cow casein hydrolysates contributed to a significant improvement of the rheological and sensory properties of yoghurt. In conclusion, camel and cow casein hydrolysate could be used as a supplement in set-type yoghurt production with a potential beneficial effect on fermentation time, survival of total bacterial count, and overall acceptability.

Keywords: camel casein hydrolysate; lactic acid bacteria; sensory evaluation; rheological properties of yoghurt

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1. Introduction

Milk protein hydrolysates are rich in small peptides (di-and tripeptides) and have a higher nutritive value than native milk protein or an equivalent mixture of free amino acids [1,2]. These peptides can be used as functional food, or as nutritional and pharmaceutical ingredients to improve human health and prevent disease [3,4]. Protein hydrolysates have been used for preparing special foods for allergic infants and individuals [5,6]. Casein derived peptides play a major role in the enhancement of the immune system [7,8]. Some peptides derived from milk protein hydrolysate are found to be active against a broad range of pathogenic organisms, such as *Listeria monocytogenes* and *Escherichia coli* O157:H7 [9,10]. These peptides also inhibit angiotensin-converting enzyme (ACE), aiding the regulation of blood pressure (antihypertensive effect) [11–13]. Some bioactive peptides derived from casein hydrolysate have antioxidant activities and suppress cholesterol absorption, such as β-casomorphin exorphin, casoxin derived from hydrolysis of β-αs, and κ-casein, respectively [14–16]. Furthermore, casein hydrolysate is used as a slurry to accelerate cheese ripening and to increase the growth rate of LAB [17,18]. Moreover, small peptides derived from casein hydrolysate act as a substrate for lactocepin enzymes to release free amino acids to be used in the metabolism of LAB [19]. Hydrophilic amino acid residues, including His, Lys, Glu, and Ser, derived from casein hydrolysate, are beneficial for bacterial growth [20].

Ma et al. (2019) [21] studied the effect of casein hydrolysate addition (2 g/kg skim milk) on acidification and textural attributes of set-style yogurt samples. They found that the addition endowed higher titratable acidity but lower pH values and thus enhanced yogurt fermentation and improved yogurt texture. Zhao et al. (2006) [22] studied the effect of added cow casein hydrolysate on the rheological properties of yoghurt. The addition of casein hydrolysate to yoghurt milk decreased its viscosity and fermentation time [18,23]. Han et al. (2020) [24] reported that *Streptococcus thermophilus* in the presence of 1 g/L casein hydrolysate as a nitrogen source, yielded γ-Aminobutyric acid (GABA concentrations as high as 5.4 g/L) which has techno-functional properties (i.e. radical scavenging, antimicrobial properties, and incorporation in beverage formulation). However, data concerning the application of camel casein hydrolysate on the properties of yogurt are still scarce in the literature. The aim of this study was to compare the effects of camel and cow casein hydrolysate supplementation on the microbiological, sensory, and rheological properties of yoghurt made from cow milk.

2. Materials and Methods

Strains and ingredients: *Lactobacillus delbrueckii*, ssp. *bulgaricus* DSM 20081 and *Streptococcus thermophilus* DSM 20617 were obtained from Deutsche Sammlung von Mikroorganismen und Zellkultturen (DSMZ). GmbH, Germany. Trypsin enzyme was provided by sigma Co. (Sigma Aldrich Cheme. GmbH, Steinheim, Germany).

2.1. Acid Casein Preparation

Acid casein was prepared from camel and cow raw skim milk according to Salmen et al. (2012) [25]. Briefly, camel and cow skim milk were acidified to pH 4.3 and 4.6, respectively, with 1 M HCl at 40 °C. The precipitated casein was collected by centrifugation at 1500$\times$ g for 20 min and then washed three times with acidified distilled water (pH 4.3 and 4.6). The precipitate was suspended in water and neutralized by NaOH (1 M). Finally, the neutralized casein was reprecipitated at pH 4.3 and 4.6 for camel and cow casein, respectively, followed by lyophilizing using a Unitop 600 SL (Virtis Company, Gardiner, NY, USA) and stored at −20 °C until use.

2.2. Casein Hydrolysate Preparation

Casein hydrolysates were prepared using a modified method developed by Al-Saleh et al. (2014) [26]. Trypsin enzyme was dissolved in 50 mM phosphate buffer at pH 7.0, The acid caseins were reconstituted in Jennes & Koops buffer [27] to have a final casein concentration of 2.5 g 100 mL. The pH of casein solutions was adjusted to pH 7.0 by adding 1 M NaOH and completely suspended before adding the enzyme. The enzyme solution was added to casein solution with an enzyme to substrate ratio [E/S] of 1/100 and hydrolysis was carried out at 37 °C for 1 h. The reactions were terminated by heating the enzyme casein mixture at 100 °C in a boiling-water bath for 10 min. The resulting mixture was rapidly cooled in an ice-water bath and then was added to cow milk just before yoghurt preparation.

2.3. Determination of Degree of Casein Hydrolysis

The degree of casein hydrolysis was determined using the ortho-phthadialdehyde (OPA) according to Donkor et al. (2005) [28]. The hydrolysis degree of samples was estimated using this equation:

$$\text{Degree of hydrolysis } (\%) = \frac{(S - C) \times 100}{D - C} \tag{1}$$

where, S is the reading of casein hydrolysate samples by trypsin enzyme, D is the reading of hydrolysed samples for 24 h incubation; C is the un-hydrolysed casein reading. SDS-polyacrylamide gel electrophoresis (PAGE) was performed using 12.5% acrylamide separating gel and 5% stacking gel to measure the level of casein hydrolysis according to Laemmli (1970) [29].

2.4. Yoghurt Preparation

Whole cow pasteurized-homogenized milk (3% fat; 8.57% SNF and 0.73% ash) was obtained from a local market. The milk was heated in a controlled water bath for 30 min at 85 °C and was then cooled to 45 °C under running tap water. The heated milk was supplemented with camel or cow casein hydrolysate separately at 0.5, 1.0, and 1.5% (v/v) levels. The milk that was not supplemented with casein hydrolysate was used as the control. The milk samples were inoculated with working starter culture (1.5%) (*Streptococcus thermophilus* and *Lactobacillus delbrueckii* ssp. *Bulgaricus* 1:1). Inoculated milk samples were incubated at 42 °C until pH values reached 4.6. Fermentation was terminated by cooling the fermented milk to 4 °C in a refrigerator. The refrigerated samples were stored at 4 °C until used.

The pH of the samples was measured with a pH meter (Corning pH meter 240, England).

2.5. Texture Profile Analysis

Texture profile analysis (TPA) was performed using Brookfield CT3 texture analyzer (Commerce Boulevard, Middleboro, MA, USA) to determine the textures of the yoghurts using an acrylic cylindrical probe 25.4 mm diameter, 35 long. The probe penetrated the samples to a depth of 15 mm at a speed of 0.5 mm/s and the force exerted on the probe was automatically recorded. The parameters recorded included hardness, cohesiveness, adhesiveness, and springiness. Gumminess and chewiness were calculated using the formulas: gumminess = hardness × cohesiveness and chewiness = gumminess × springiness. Four yoghurt samples were analyzed at 4 ± 2 °C for each trial and the average readings were recorded.

2.6. Water-Holding Capacity of Yoghurt

The susceptibility of yoghurt to water-holding capacity was determined using the method of (Isanga and Zhang, 2009) [30], with minor modification. In 50 mL conical plastic tubes, (falcon type) 45 g of yoghurt (Y) was centrifuged at 3000× g for 20 min at 4 °C (using Hraeus Christ GMBH centrifuge, H. Jurgens & Co. Bremen, Bremen, Germany). The clear supernatant (W) was poured off, weighed and the water-holding capacity (WHC, g 100 g) was calculated as: WHC = $(Y - W)/Y \times 100$.

Enumeration of LAB of yoghurt. The total bacterial counts (*L. delbrueckii* ssp. *bulgaricus*, and *S. thermophilus*) were determined using Plate Count de Man–Rogosa–Sharpe (MRS) agar medium (Difco Laboratories, Detroit, MI, USA). The plates were incubated aerobically and counted after 72 ± 3 h at 37 °C. the total counts were calculated by converting the CFU/mL to log10.

Sensory characteristics. The organoleptic characteristics of the yoghurts were determined, using a taste panel consisting of 12 judges. The panelists were asked to evaluate the products for appearance, texture, flavor, and overall acceptability using a five-point hedonic scale (1, 3, and 5 represent dislike extremely, neither like nor dislike, and like extremely, respectively).

Statistical Analysis. All analyses were performed in triplicate using the MINITAB 14 (Minitab Inc., State College, PA, USA), data were subjected to one-way analysis of variance (ANOVA), and the significance levels were set as $p < 0.05$.

3. Results and Discussion

3.1. Degree of Hydrolysis

After incubation of caseins with trypsin enzyme for 1 h, the degrees of hydrolysis were measured using O-phthaldehyde method (OPA). In this method, TCA was added in a final concentration of 12% precipitating all proteins thus, the method measures only amino acids and very small peptides. The results in Figure 1 show that about 75.81% and

70.12% of the cow and the camel casein hydrolyzed during incubation time with trypsin, respectively. The rest of the caseins revealed a degree of hydrolysis, but not enough to be measured with the OPA method.

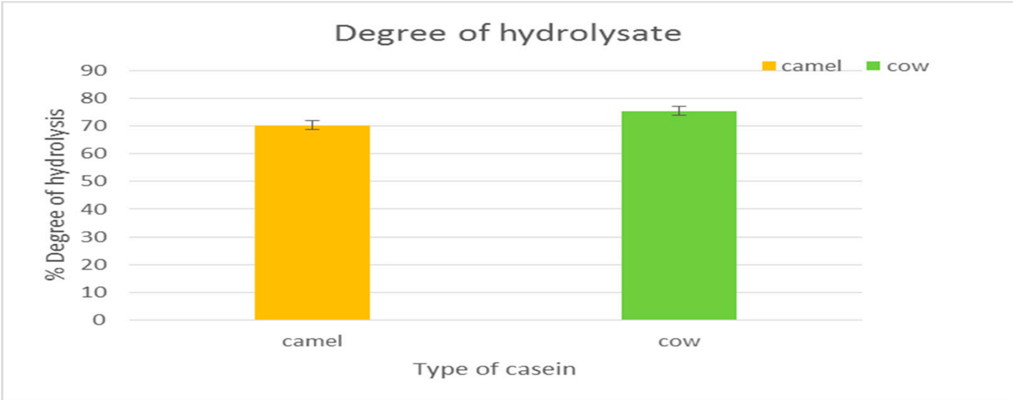


Figure 1. Hydrolysis degree of cow and camel milk casein with trypsin enzyme.

Electrophoresis SDS clearly revealed that the cow and the camel casein extensively hydrolyzed during incubation time (for 1 h) with trypsin enzyme (Figure 2). These results are consistent with those of Ugwu et al. (2019) [31] and Irshad et al. (2015) [32], who found that about 64.14% of camel casein and 83.33% of cow casein hydrolysis was achieved after one hour with trypsin enzyme. Complete degradation of cow and camel milk α_s- and β –caseins was observed with the addition of trypsin enzyme and incubation for 15 min [33]. No peptide fragments were found on SDS-PAGE (Figure 2). Rivera, et al. (2018) [34] stated that the SDS-PAGE method proposed by Laemmli (1970) [29] is not suitable to detect small peptide proteins and some modification is required to detect lower molecular weight proteins < 10 KDa.

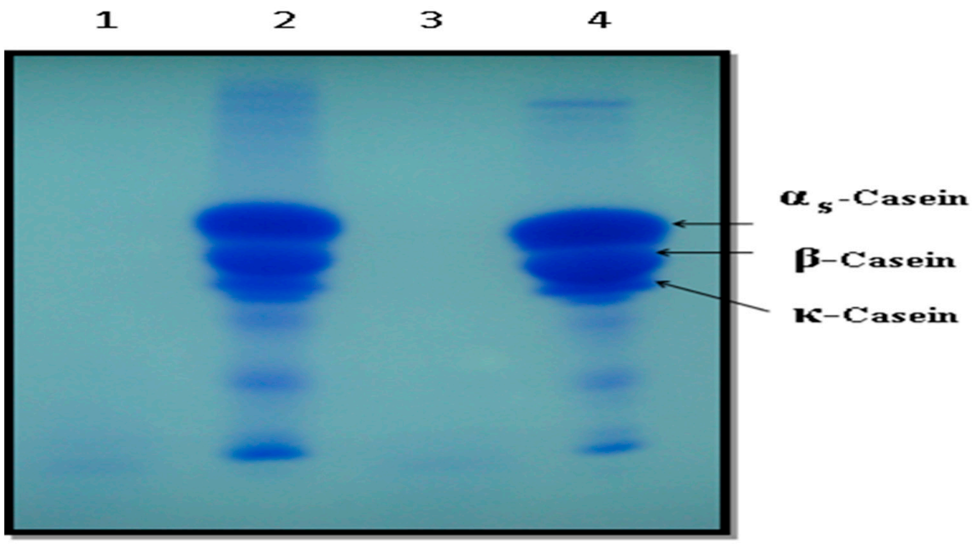


Figure 2. SDS-PAGE profile of cow and camel milk casein hydrolysis. **Lane 1**: camel milk casein treated with trypsin for one hour, **Lane 2**: camel milk casein (untreated), **Lane 3**: cow milk casein treated with trypsin for one hour, **Lane 4**: cow milk casein (untreated).

3.2. Fermentation Time

The results in Figure 3 represent changes in fermentation times of yogurts supplemented with different ratios of camel casein hydrolysate. The results revealed that the addition of the casein hydrolysates significantly decreased the fermentation times of the yogurts in comparison with the control sample. This is in accordance with results obtained by Ma et al. (2019) [21] and Zhao et al. (2006) [22]. Moreover, the decrease in fermentation times was proportional to casein hydrolysate addition (Figure 3). This shows that casein hydrolysates encourage the growth of the starter culture. This may be attributed to the presence of higher levels of free amino acids and small peptides in casein hydrolysates.

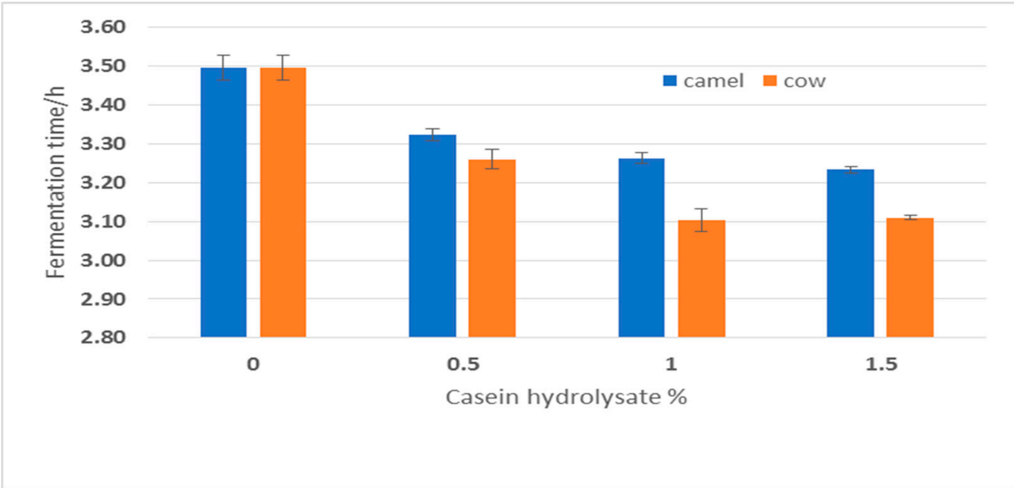


Figure 3. Fermentation times of yogurt with added casein hydrolysates.

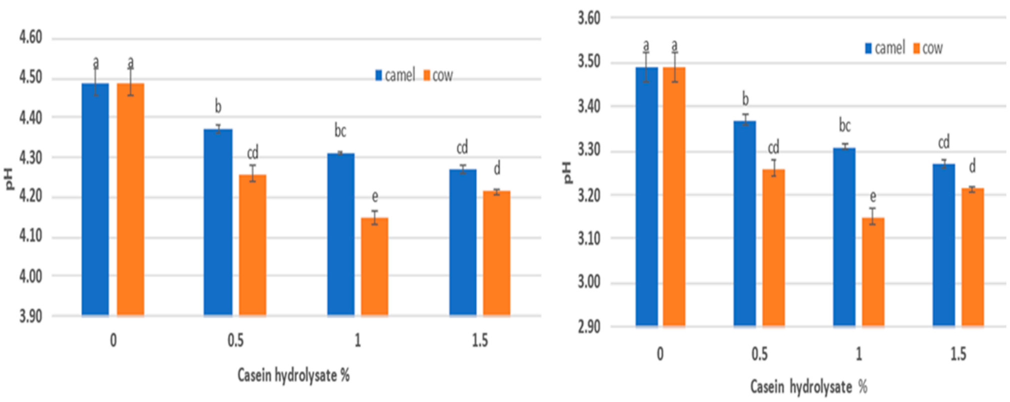
These small peptides and free amino acids are known to be bioactive peptides and can enhance the growth and acidifying activity of starter culture. Canon et al. 2021 [35] reported that the activity of LAB (higher acidification rates and lower pH) was strongly associated with higher concentrations of tryptophan, valine, phenylalanine, leucine, isoleucine, and small peptides. Moreover, Adams et al. (2020) [36] stated that the growth rates of LAB strains increased in the medium supplemented with 0.1% casein hydrolysate.

3.3. Changes in pH

The results in Figure 4a represent changes in pH of yoghurts made from cow milk supplemented with different levels of camel and cow casein hydrolysates. The addition of hydrolysates to milk yoghurts has a strong effect on pH changes during fermentation. The rate of pH decrease was significantly ($p < 0.05$) higher in treated samples in comparison with those of control, which indicates that the camel and the cow casein hydrolysate promote the growth of yoghurt culture. Moreover, the addition of cow casein hydrolysate significantly decreased the pH of yoghurt samples, more than that of the camel casein hydrolysate ($p < 0.05$). The pH proportionally decreased with increasing casein hydrolysate. Ma et al. (2019) [21] reported that peptides were superior to reduce the fermentation time and casein-hydrolyzed peptide was shown to be the best one. These results are in a good agreement with those obtained by [18,21–23]. Casein hydrolysates probably contain small peptides and free amino acids, which promote the growth of yoghurt culture [35,36]. Zhang et al. (2011b) [37] found that addition of casein hydrolysate with small peptides lower than 3000 Da, markedly increased lactic acid formation. Moreover, the pH of yoghurt samples significantly decreased (0.33 pH unit in control samples) during storage at 4 °C for three weeks and the pH of treated samples exhibited a greater decrease than that of the control product (Figure 4b). This may be attributed to the greater viability of lactic culture in treated samples.

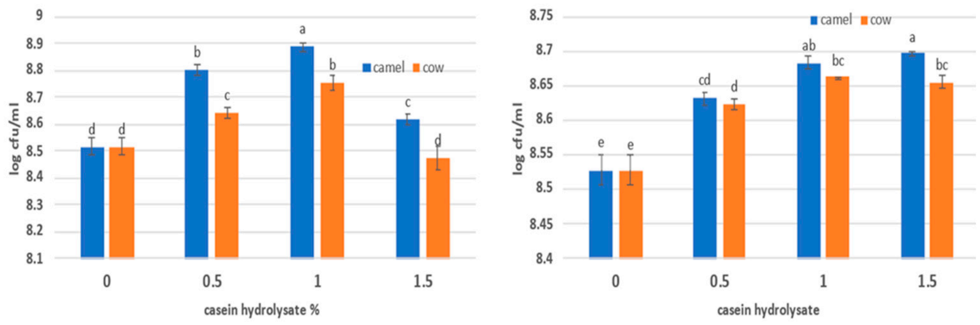
3.4. Viability of Yoghurt Culture during Fermentation and Storage

The growth of *S. thermophilus* and *L. delebrueckii* ssp. *bulgaricus* during fermentation of yoghurt is presented in Figure 5b. Addition of camel and cow casein hydrolysates to milk yoghurt significantly increased the total bacterial counts compared to the control ($p < 0.05$). The highest total bacterial count was observed with 1.0% camel casein hydrolysate; this indicates that the camel casein hydrolysate enhanced the growth of yoghurt culture. However, the growth of yoghurt culture decreased with an increased addition of both hydrolysates (cow and camel hydrolysates) to 1.5%. These findings were confirmed by Zhao et al. (2006) [22], who found that the growth of probiotic bacteria decreased with the increase in the addition of casein hydrolysates. Zhang et al. (2011a) [20] and Zhao et al. (2006) [22] reported that the growth of LAB (*L. delbrueckii* ssp. *bulgaricus* and *S. thermophilus*) in yoghurt increased with the supplementation of the peptides fraction (<3000 Da), produced with papain, from 8.29 in the control sample to 8.42 log CFU mL in the treated sample. In addition, the time needed to reach pH 4.5 reduced from 5.21 to 4.29 h. Adams et al. (2020) [36] found that addition of peptides derived from fermented milk into MRS medium promotes the growth of LAB. The increase in the level of peptide and free amino acids (particularly, the hydrophilic amino acid residues including His, Lys, Glu and Ser) by the addition of hydrolysate may enhance the growth and acidic activity of the *S. thermophilus* [18,20]. Additionally, the presence of caseinophosphopeptide-rich fraction released in the trypsin treated milk, may stimulate the growth of LAB [38–40]. Moreover, the growth of *S. thermophilus* and *L. delebrueckii* ssp. *bulgaricus* significantly increased with the addition of peptides derived from αs_1 and αs_2 bovine casein [37]. Settier-Ramírez et al. (2021) [41] found that incorporation of casein hydrolysate resulted in an increase in cell viability of LAB. Moreover, Naibaho et al. (2022) [42] reported that the higher solubility of proteins increased when pH reached 4.3–4.5; this improved the LAB growth in yoghurt. No significant changes ($p < 0.05$) were observed in the total counts of untreated samples during storage for three weeks (Figure 5b). However, the total counts of treated samples decreased significantly, particularly with 0.5% and 1% camel casein hydrolysate where the initial counts were significantly high (Figure 5a).



(**a**) (**b**)

Figure 4. The change in pH during the fermentation of casein hydrolysate-treated yoghurt after one-day storage at 4 °C (**a**) and after storage for three weeks (**b**). No significant differences with the same letters among treatments.



(**a**) (**b**)

Figure 5. Viability of total bacterial count of yoghurt made from cow milk with different levels of camel and cow casein hydrolysate after storage for one day at 4 °C (**a**) and after three weeks (**b**). No significant differences with the same letters among treatments.

This could be attributed to the decrease of pH of treated samples (Figure 3). Zhao et al. (2006) [22] found that the addition of casein hydrolysates reduced the fermentation time of yoghurt and increased the total bacterial count, but the total bacterial number decreased during storage period. The total population of microorganisms in live and active culture yoghurt must be 10^8 CFU/g at the time of manufacture, as recommended by the National Yoghurt Association [43]. The total bacterial counts in the yoghurt samples after three weeks of storage met the National Yoghurt Association's requirements, with total bacterial counts of 3.4×10^8 in control samples compared to 4.3, 4.8, and 4.9×10^8 in samples treated with 0.5, 1.0, and 1.5% camel casein hydrolysate, respectively. In samples treated with cow casein hydrolysate, these values were 4.2, 4.4, and 4.5×10^8 in the same order (Figure 5b).

3.5. Rheological Characteristics

The changes in rheological properties of the yoghurts supplemented with casein hydrolysates at different concentrations were determined (Table 1). The hydrolysates significantly ($p < 0.05$) increased the hardness and adhesiveness of the yoghurts, except for the 0.5% cow casein hydrolysate sample.

Table 1. Changes in rheological properties of fresh yoghurt (after a night at 4 °C).

Samples	Hardness	Cohesiveness	Springiness	Adhesiveness	Gumminess	Chewiness
0	27.75 ^{b}	0.4475 ^{a}	8.7 ^{a}	0.25 ^{ab}	12.42 ^{a}	108.04 ^{a}
0.5 L	29.67 ^{ab}	0.483 ^{a}	8.666 ^{a}	0.3 ^{ab}	14.33 ^{a}	124.17 ^{a}
1.0 L	31.5 ^{a}	0.44 ^{a}	8.375 ^{a}	0.4 ^{a}	13.86 ^{a}	116.08 ^{a}
1.5 L	29 ^{ab}	0.405 ^{a}	8.675 ^{a}	0.38 ^{ab}	11.75 ^{a}	101.89 ^{a}
0.5 W	24.25 ^{c}	0.445 ^{a}	8.6 ^{a}	0.15 ^{b}	10.79 ^{a}	92.80 ^{a}
1.0 W	31.0 ^{a}	0.39 ^{a}	8.7 ^{a}	0.4 ^{a}	12.09 ^{a}	105.18 ^{a}
1.5 W	31.5 ^{a}	0.435 ^{a}	8.7 ^{a}	0.33 ^{ab}	13.70 ^{a}	119.21 ^{a}

L: camel milk casein hydrolysate; W: cow milk casein hydrolysate; A different superscript letters indicate a significant difference ($p < 0.05$) through columns.

It seems that casein hydrolysate can penetrate the casein micelles network and fill the pores of the protein, thereby increasing yoghurt hardness and adhesiveness. The adhesiveness had a positive effect on the thickness of the yoghurts and was an important factor leading to the products' stability [44]. This resulted in a good mouthfeel and improved the texture characteristics and the yoghurts' stability during storage. The rate of pH decrease was higher with the addition of casein hydrolysates (Figure 3). This may have affected the strength of the yoghurt curd. After one day of storage, there were no significant variations in the cohesiveness, springiness, gumminess, or chewiness of the yoghurt with and without casein hydrolysates ($p < 0.05$). However, there were significant differences in hardness between fresh and stored samples after three weeks of storage, except for 1.5% cow milk casein hydrolysate (Table 2). In general, there were no significant differences in cohesiveness, springiness, gumminess, and chewiness after storage for three weeks at 4 °C.

In comparison to the other samples, the adhesiveness of yoghurt treated with 0.5% cow casein hydrolysate was significantly reduced.

Table 2. Effect of storage period for three weeks at 4 °C on rheological properties of yoghurt.

Sample Type	Hardness		Cohesiveness		Springiness		Adhesiveness		Gumminess		Chewiness	
	B	A	B	A	B	A	B	A	B	A	B	A
control	27.75 ^{b}	32 ^{e}	0.4475 ^{a}	0.443 ^{a}	8.7 ^{a}	8.13 ^{a}	0.25 ^{ab}	0.4 ^{bcd}	12.42 ^{a}	14.2 ^{a}	108.04 ^{a}	115.89 ^{a}
0.5 L	29.67 ^{ab}	33.75 ^{c}	0.483 ^{a}	0.468 ^{a}	8.666 ^{a}	8.48 ^{a}	0.3 ^{ab}	0.45 ^{bc}	14.33 ^{a}	15.81 ^{a}	124.17 ^{a}	134.4 ^{a}
1.0 L	31.5 ^{a}	35.75 ^{c}	0.44 ^{a}	0.448 ^{a}	8.375 ^{a}	8.38 ^{a}	0.4 ^{a}	0.575 ^{a}	13.86 ^{a}	16.03 ^{a}	116.08 ^{a}	134.78 ^{a}
1.5 L	29 ^{ab}	37.25 ^{b}	0.405 ^{a}	0.44 ^{a}	8.675 ^{a}	8.33 ^{a}	0.38 ^{ab}	0.475 ^{b}	11.75 ^{a}	16.42 ^{a}	101.89 ^{a}	136.73 ^{a}
0.5 W	24.25 ^{c}	36 ^{c}	0.445 ^{a}	0.417 ^{a}	8.6 ^{a}	8.1 ^{a}	0.15 ^{b}	0.25 ^{e}	10.79 ^{a}	15.03 ^{a}	92.80 ^{a}	121.47 ^{a}
1.0 W	31.0 ^{a}	38.25 ^{a}	0.39 ^{a}	0.428 ^{a}	8.7 ^{a}	8.13 ^{a}	0.4 ^{a}	0.38 ^{cd}	12.09 ^{a}	16.39 ^{a}	105.18 ^{a}	133.28 ^{a}
1.5 W	31.5 ^{a}	32.75 ^{e}	0.317 ^{a}	0.435 ^{a}	8.7 ^{a}	7.95 ^{a}	0.33 ^{ab}	0.35 ^{d}	13.70 ^{a}	13.05 ^{a}	119.21 ^{a}	103.13 ^{a}

L: camel milk hydrolysate; W: cow milk hydrolysate; B: fresh yoghurt; A: after storage.

The hardness of treated and untreated samples significantly increased during storage and the increase was higher with increased addition of casein hydrolysate, except for the sample with an addition of 1.5% cow casein hydrolysate (Table 2). The increase of hardness during storage may be due to the formation of a higher cross-linkage of the casein network in yoghurts and/or the evaporation of some moisture in the head space of the yoghurt cup.

3.6. Water-Holding Capacity

The water-holding capacity of yoghurt samples after centrifugation at 4 °C for 20 min at 3000× *g* showed a significant ($p < 0.05$) decrease with the addition of 1.5% camel and cow casein (Figure 6). However, there were no significant differences between control samples and samples treated with 0.5% and 1% casein hydrolysates. Dave and Shah (1998) [45] found that the protein network of yoghurt supplemented with acid casein hydrolysate has small flocs and pores.

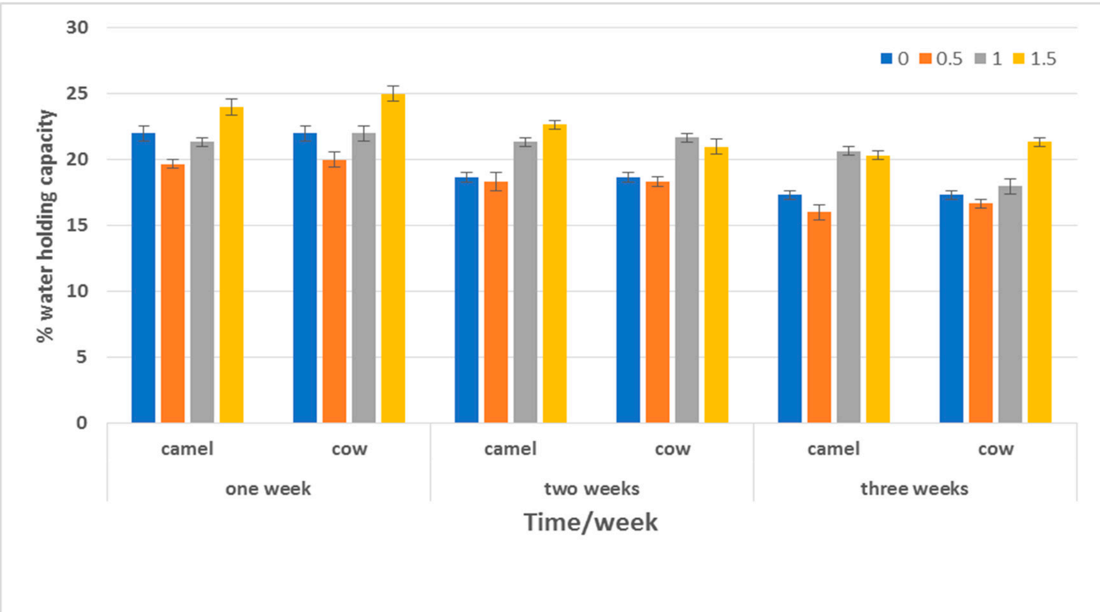


Figure 6. Changes in water-holding capacity of yoghurt made with addition of casein hydrolysates during storage.

The same observation was confirmed by Sodini et al. (2005) [23], who observed a more open and less branched structure in yoghurts when the milk protein hydrolysates were incorporated at high concentration (4%). It seems that the open structure of the protein network of yoghurt makes the drainage of whey easier during the syneresis process.

Moreover, the water-holding capacities of yoghurt significantly ($p < 0.05$) increased during the storage period. Protein molecules have positive net charges at pH < 4.6, which may react with the negative charges in casein hydrolysates [39]. Addition of casein hydrolysates improved water-holding capacities of yoghurts. Corredig and Salvatore (2016) [46] reported that the number of bonds between each junction in freshly made gels is not yet very high, as in aged gels. This may explain why wheying-off occurs in young gels, but not as much in aged gels.

3.7. Sensory Evaluation

The effects of camel and cow casein hydrolysates supplementation on the sensory characteristics of yoghurt are presented in Table 3. With the addition of casein hydrolysate, the sensory scores for acceptability of yoghurt significantly ($p < 0.05$) increased. No significant differences were found between control samples (zero addition) and yoghurt samples supplemented with 1% camel casein hydrolysate and 0.5% cow casein hydrolysate. The texture of all treated samples was comparable with control samples except with 0.5% camel casein hydrolysate, where it significantly ($p < 0.05$) decreased. The control samples and the samples treated with 0.5% cow casein hydrolysate and 1.0% camel casein hydrolysate had the maximum overall scores, whereas yoghurt containing 0.5% camel casein hydrolysate had the minimum. The acceptability score for the fresh sample 1 L (1% camel casein hydrolysate) was 4.67 ^{ab} while it was 4 ^{bc} for the control sample. However, after 21 days no significant changes were recorded (the same significant letter). The sample with 0.5% camel casein hydrolysate had a significantly ($p \leq 0.05$) lower acceptability score than the control (3.42).

Table 3. Effect of milk casein hydrolysate addition on sensory evaluation of yoghurt.

	Fresh				After 21 Days			
% Casein hydrolysate	Appearance	Texture	Flavour	Acceptance	Appearance	Texture	Flavour	Acceptance
zero	4.58 ^{ab}	4.17 ^{a}	4.25 ^{a}	4 ^{bc}	4.67 ^{a}	4.08 ^{ab}	4 ^{ab}	4.25 ^{ab}
0.5 L	4.67 ^{ab}	3.25 ^{b}	3.42 ^{b}	3.42 ^{c}	4.67 ^{a}	4.33 ^{a}	4.5 ^{a}	4.5 ^{a}
1 L	4.75 ^{a}	4.5 ^{a}	4.42 ^{a}	4.67 ^{ab}	4.17 ^{ab}	4.08 ^{ab}	3.83 ^{ab}	4.0 ^{abc}
1.5 L	4.25 ^{ab}	4.58 ^{a}	3.83 ^{ab}	4.17 ^{b}	4.25 ^{ab}	3.58 ^{ab}	3.92 ^{ab}	3.75 ^{abc}
0.5 W	4.92 ^{a}	4.83 ^{a}	4.5 ^{a}	4.92 ^{a}	4 ^{b}	3.17 ^{b}	3.33 ^{b}	3.33 ^{c}
1 W	4.5 ^{ab}	4.25 ^{a}	3.5 ^{b}	4.25 ^{ab}	4.67 ^{a}	4.42 ^{a}	3.67 ^{b}	3.92 ^{abc}
1.5 W	4 ^{b}	4.17 ^{a}	3.83 ^{ab}	4.17 ^{b}	4.33 ^{ab}	3.17 ^{b}	3.33 ^{b}	3.5 ^{bc}

As storage progressed, the overall acceptability scores significantly decreased in all cow casein hydrolysate treatments. However, there was marked improvement in samples treated with 0.5 and 1% camel casein hydrolysate after the storage period.

4. Conclusions

The results demonstrated that the casein hydrolysates significantly ($p < 0.05$) reduced the fermentation time of the yoghurt. The hydrolysates increased the total bacterial counts after fermentation, particularly with the addition of 1.0% hydrolysate. The total bacterial counts in the yoghurt samples decreased during storage. However, the decline in the total bacterial counts during storage could be retarded by the addition of hydrolysates. The hydrolysates significantly ($p < 0.05$) increased the hardness and adhesiveness, except for the 0.5% cow casein hydrolysate sample. The sensory attributes of the yoghurts were significantly ($p < 0.05$) improved by the addition of hydrolysates, especially with 1.0% camel casein hydrolysate. In general, the results of the present study demonstrate the possibilities of the use of camel casein hydrolysate in the manufacture of yoghurt, for better viability of lactic acid bacteria, and improved rheological and sensory properties.

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