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THE IMPACT OF STARTER CULTURES ON QUARK TYPE CHEESE PRODUCTION

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ABSTRACT
This study was conducted to investigate the effect of starter cultures on the physicochemical and microbiological properties, texture, yield, and consumer preferences of quark type cheese. For this purpose, three different quark cheeses were manufactured by using commercial starter cultures. The microbiological, physicochemical, textural, and sensory properties of the cheese samples were determined at 1st, 14th, and 28th days of the storage period. The results showed that the kind of starter culture used in production influences the composition and yield of the obtained quark cheeses. It has been determined that the use of kefir culture in quark cheese production influences the moisture and water holding capacity, and as a result, improves its spreadability. Also, the sensory analysis exhibited that cheese produced with kefir culture had higher texture and taste-flavor acceptability. The study indicates that kefir culture may be successfully used in quark cheese production.
Keywords: Quark cheese, starter culture, DVS culture, commercial culture

STARTER KÜLTÜRLERİN QUARK TİPİ PEYNİR ÜRETİMİNE ETKİSİ

ÖZ
Bu çalışma, starter kültürlerin quark tipi peynirlerin fizikokimyasal ve mikrobiyolojik özelliklerine, tekstürüne, verimine ve tüketici tercihlerine etkisinin araştırılması amacıyla yapılmıştır. Bu amaçla ticari starter kültürler kullanılarak üç farklı quark peyniri üretilmiştir. Peynir örneklerinin mikrobiyolojik, fizikokimyasal, tekstürel ve duyusal özellikleri depolama süresinin 1, 14 ve 28. günlerinde belirlenmiştir. Sonuçlar, starter tipinin peynirin bileşimini ve verimini etkilediğini göstermiştir. Ouark peyniri üretiminde kefir kültürü kullanımının, peynirin nem ve su tutma kapasitesini etkilediğini, buna bağlı olarak da sürülebilirliğin arttığı belirlenmiştir. Ayrıca, duyusal analizler, kefir kültürüyle üretilen peynirin doku ve lezzet bakımından daha yüksek kabul edilebilirliğe sahip olduğunu göstermiştir. Çalışma, kefir kültürünün quark peyniri üretiminde başarıyla kullanılabileceğini göstermektedir.
Anahtar kelimeler: Quark peyniri, starter kültür, DVS kültür, ticari kültür

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INTRODUCTION

Quark is a soft, spreadable, and fresh cheese characterized by a colour spectrum ranging from porcelain white to creamy yellow, coupled with a slightly sour taste. Quark can be made from skimmed milk, cream, or whole milk (Chauhan et al., 2022). It is produced through an acid coagulation process facilitated by mesophilic lactic acid bacteria (LAB) introduced to milk While traditionally produced without rennet, modern dairy industries now incorporate rennet to enhance syneresis, minimize casein losses from whey, and achieve a firmer curd structure (Miloradovic et al., 2018).

The existence of live microorganisms and the activity of beta-galactosidase in quark cheese serve as safeguards against lactose intolerance. Additionally, quark boasts high nutritional value owing to its elevated protein content. (Chauhan et al., 2022). By implementing specific modifications in the quark cheese production process, such as reducing fat content, increasing protein and calcium levels, and introducing diverse antioxidants and probiotic microorganisms, it becomes feasible to craft a cheese with enhanced functional properties and positive health contributions (Duric et al., 2007; Guneser and Aydin, 2022; Kim et al., 2019).

Enhancing the texture and taste of cheese through the careful selection of appropriate starter cultures is a crucial method for advancing the growth of the cheese industry (Jia et al., 2021). Producing lactic acid from lactose is probably the most crucial step in cheese making. This process is accomplished by specially selected cultures of different types of lactic acid bacteria that are added to milk. Starter cultures are microorganisms with known properties that provide the product with the desired taste, aroma, and structure. The production of standard and quality products in the dairy industry depends on using starter cultures with appropriate characteristics (Fox et al., 2016). While starter cultures generate compounds that enhance the flavor of the product, it is noteworthy that fresh cheeses often exhibit similar flavors and aromas (Jia et al., 2021). Hence, the choice of starter culture for the production of fresh fermented products holds significant importance in shaping the taste and aroma perception of consumers. Furthermore, Bekele et al. (2019) and Hordofa (2018) established that employing distinct starter cultures in the production of soft fresh cheese had an impact on the overall cheese yield.

Numerous studies have explored the use of diverse starter cultures in cheeses maturation, consistently revealing their profound influence on various properties of cheeses (Celik and Tarakci, 2017; Jia et al., 2021). While there is an abundance of literature on quark cheese, particularly regarding its production using different raw materials or by-products (Guneser and Aydin, 2022; Ozturkoglu-Budak et al., 2021), there is a paucity of information concerning the use of different starter cultures in fresh cheeses, specifically in quark production. Given the significant impact of starter cultures on cheese yield, flavor, and texture, this study aimed to investigate the potential application of various starter cultures to enhance the quality and organoleptic properties of quark cheese. To achieve this objective, three distinct commercial starter cultures were utilized in quark cheese production. Subsequently, compositional, textural, and sensory analyses were conducted to identify the most suitable starter culture for quark cheese manufacturing.

MATERIALS AND METHODS

Materials

Raw milk used in the production of quark was obtained from Ankara University, Faculty of Agriculture, Pilot Dairy Plant. Three different commercial DVS cultures were used in the production of quark cheese. Codes, compositions and suppliers of the starter cultures are given in Table 1.

Production of quark cheese

In total, 15 L raw cow's milk (3.5 % fat, 12.05% dry matter, 3.2% protein and pH 6.6) was pasteurized in a plate pasteurizer at 75±2 °C for 1 min. and was cooled to 28 °C and then divided into 3 equal parts. Afterward, 0.3% (w/v) DVS-C, DVS-K, and DVS-B starter cultures were

inoculated to each part of milk as instructed by the manufacturer and 0.01% (v/v) rennet (Naturen mandra 175, Chr Hansen) was added to each pasteurized milk simultaneously with starter cultures. The samples were kept for about 16 h at 25°C until the pH reached 4.6 where coagulum was formed. The curd was cut and put into the cheese cloths to separate the whey.

Table 1. Starter cultures and contents used in the study

Sample name	Culture codes	Composition	Supplier
DVS-C	R-703	*Lictococuslactis* subsp.*cremoris* *Lactococuslactis* subsp.*Lactis*	Chr-Hansen
DVS-K	Choozit Kefir DC1	*Lactococcuslactis* subsp. *Leuconostoc* subsp. *Lactobacillus* subsp. *Streptococcus thermophilus,* Kefir grains microflora and Kefir yeasts	Danisco
DVS-B	CH N11	*Lactococcuslactis* subsp. *cremoris*, *Leuconostoc,* *Lactococcuslactis* subsp. *lactis,* *Lactococcuslactis* subsp. *lactis* biovar *diacetylactis*	Chr-Hansen

DVS: Direct vat set

For further drainage of the whey, the curd was left in the cheese cloth for 24 hours at 18 to 20°C. When the separation into whey was completed, cheese samples were vacuum-packed using polyethylene bags and stored at 4°C for 28 days and analyzed during storage periods with fourteen days intervals. The preliminary experiment determined that quark cheese can be consumed for about 4 weeks based on sensory properties. Consequently, this study investigated the alterations occurring in quark cheese over the 28-day storage period. The experiment was carried out in duplicate.

Gross composition, physicochemical analysis and yield

The pH of the samples was measured by direct insertion of a pH electrode into the cheese. Titratable acidity was determined according to the AOAC (1995) and expressed as percentage of lactic acid. Total dry matter contents were determined as per standard IDF (1982) methods. Total fat was determined according to the Gerber- Van gulik method and total protein and water-soluble nitrogen were prepared as indicated by Kuchroo et al. (1982) and measured by the Kjeldahl method. Ripening index was calculated following formula:

(WSN/TN) x 100 (TN; total nitrogen, WSN; water soluble nitrogen).

Cheese yield was calculated as actual (Ya) (Fox et al., 2016) and dry matter cheese yield (Ydm) were determined using this formula;

Ya= $100 \times (Weight\ of\ cheese \div weight\ of\ milk)$

Ydm= $Ya\ (100 - MD) \div 100$ (MD; moisture content of cheese) (Fenelon Guinee, 1999).

The water-holding capacity (WHC) of the samples were measured according to Tiwari et al. (2021) and values were calculated as follows:

WHC (%) = $(1\text{-}W_1 / W_2) \times 100$

(W_1: Weight of whey after centrifugation, W_2: Sample weight).

All measurements were carried out in duplicate to ensure the robustness and reliability of the results.

Microbiological analysis of quark cheese

In total, 10 g sample were homogenized with 90 mL Ringer's solution in a Stomacher (Bag Mixer 400 VW, Interscience, France) for 90 s Total mesophilic aerobic bacteria (TMAB) were enumerated using Plate count agar (Merck, Darmstadt, Germany) incubated at 35-37 °C for 2 days. *Lactococci* spp. were counted on M17 agar (Merck, Darmstadt, Germany) incubated under aerobic conditions at 37 °C for 48 h (Halkman,

2005). *Lactobacilli* spp. were counted on DeMan-Rogosa-Sharpe (MRS) agar (Merck, Darmstadt, Germany) under anaerobic incubation (using anaerobic jar) 37 °C for 72 h. Yeast and mold were enumerated on Potato dextrose agar (PDA) (Merck, Darmstadt, Germany) incubated at 25 °C for 5 days.

Colour analysis

L, a** and *b**values expressing colour values were measured with a chroma meter (Konica Minolta CR 410 Sensing Inc., Osaka, Japan). Colour analysis of the samples was determined by the CIE-LAB optical system (*L**=lightness, *a**=red-green, and *b**=yellow-blue). ΔE and C (chroma) values of the samples were calculated with the formulas given below:

$$\Delta E = \sqrt{\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}}$$
$$C = \sqrt{a^{*2} + b^{*2}}$$

SDS-PAGE Electrophoresis

SDS-Page method was used for electrophoretic identification of whey proteins and caseins (Mini-PROTEAN Tetra cell, Bio-Rad Laboratories Ltd., UK) (Hayaloglu et al., 2011). Samples were prepared as follows; 20 g of each sample was centrifuged at 3000 x g for 30 min. at 4 °C. The supernatant was mixed 1:1 with sample buffer (25 mL stacking gel buffer, 20 mL glycerol, 40 mL 10% w/v SDS solution, 10 mL 2-mercaptoethanol, 5 mL bromophenol blue), 0.4 g of sample was mixed with 10 mL of sample buffer and centrifuged at 10.000 x g for 10 min. at 4 °C. Acrylamide concentration of the stacking and separating gel was 4% (w/v) and 12.5% (w/v), respectively. Thirteen microliters of sample were loaded in each well. Gels were run at 200 V. Gels were kept in fixing solution (containing 100 mL of 100% TCA (w/v), 330 mL of methanol and 540 mL of distilled water) for 60 min and then stained with Coomassie Brilliant Blue R250 for about 12 h.

Texture profile and spreadability analysis

Textural properties of quark cheeses were analyzed for firmness, stickiness, work of shear and work of adhesion at 1st, 14th and 28th days of storage. Texture and spreadability analysis were performed using TA-XTi plus texture analyzer (Stable Micro Systems, UK) with P/60C conical perspex cap. The sample was placed into the female cone and pressed down to eliminate air pockets. Excess sample was scraped off with a knife to leave a flat test area. Allowed the samples to equilibrate to the approximate 20 °C temperature before testing. The compression distance was set at 23 mm, the test speed during compression was 3 mm/sec, and the post-test speed was 10 mm/ sec.

Sensory analysis

The sensory evaluation of the cheese samples was carried out by seven panelists, who are experienced in the sensory evaluation of milk and dairy products, consisting of members of the Department of Dairy Technology at University of Ankara. The panelists, aged between 35-55, consisted of 5 women and 2 men. Sensory evaluation was performed on days 1st, 14th, and 28th according to scoring card described by Bodyfelt et al. (1988). For sensory evaluation, samples were randomly coded with 3-digit numbers, placed in plastic containers, and presented to the panelists with a glass of water to improve mouth taste. Panelists evaluated the cheeses for taste and flavor (0 to 10 points), colour-appearance (0 to 5 points) and body-texture (0 to 5 points).

Statistical analysis

Statistical analyses of the data were performed using Minitab package program (version 19, Minitab Inc., State College, PA). Analysis of variance (Two-way ANOVA) was carried out to identify statistical differences among cheese batches and storage. Finally, Tukey's Multiple Range Test was applied for the determination of statistically significant differences; $P < 0.05$ was accepted as significance level.

RESULTS AND DISCUSSION

Gross composition, physicochemical analysis and yield

Gross composition and yield of quark cheese are given in Table 2. The utilization of different starter cultures in quark cheese production altered the composition of the cheese. Specifically, cheese

made with kefir starter culture (DVS-K) exhibited lower fat and dry matter values compared to the other samples. Since the acidification kinetics were affected during fermentation, the matrix may have had wider pores and weaker bonds. This may increase losses with whey. Since it is found in yeasts in kefir culture, lipolysis may have occurred more intensively during fermentation and serum and free fatty acids may have been lost. There were no significant differences between the composition of the DVS-C and DVS-B samples (*P>0.05*). The actual yield outcomes indicated a noteworthy increase in samples with added kefir culture compared to the counterparts (*P<0.05*). Notably, the cheese incorporating the kefir starter exhibited a surprisingly higher overall quantity. However, dry matter yield of cheese was slightly lower. LAB and yeasts in the microflora of kefir grain produce exopolysaccharide (EPS) (Hamet et al., 2015). Due to the viscosity-increasing, water-binding and bio-thickening properties of EPS (Tiwari et al., 2021), the moisture level in the cheese increased with this culture, thus increasing the actual yield. Likewise, Ahmed et al. (2005) noted a 2% increase in moisture and yield in cheeses crafted from EPS-producing cultures. In contrast, owing to the elevated moisture content in the DVS-K sample, the dry matter yield was comparatively lower than other samples.

Table 2. Gross composition and yield (mean ± SE) of quark cheese samples on day 1.

	DVS-C	DVS-K	DVS-B
Fat (%)	17.75±0.25^{A}	16±0.00^{B}	17.25±0.25^{A}
Protein (%)	11.49±0.33	10.77±0.31	11.19±0.13
Dry matter (%)	34.00±0.96^{A}	28.81±1.19^{B}	33.83±0.2^{A}
Ya (%)	19.22±0.38^{A}	21.30±0.38^{B}	19.70±0.26^{A}
Ydm (%)	6.85±0.47	6.51±0.57	6.62±0.11

DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVS-B; cheese made using culture CH-N11.

Different uppercase letters show significant differences among the samples. (*P <0.05*)

Non-lettering columns indicates the differences among the samples are not found significant (*P>0.05*)

Ya: actual yield, Ydm: dry matter cheese yield. SE:Standard error

Table 3 presents the physicochemical properties of quark cheeses produced with various starter cultures during storage. Notably, the utilization of different starters in quark cheese production influenced both pH and titratable acidity values. Significantly, only the pH value demonstrated a discernible impact over the storage period, while the lactic acid values in quark cheese samples remained nearly stable throughout the duration of storage. The decrease in pH is associated with the lactose fermentation metabolism of the starter culture, which produces lactic acid and lowers the pH (Costa et al., 2015). Besides, the rate of milk acidification in cheesemaking, resulting in the production of lactic acid and a subsequent decrease in pH, depends on the type of starter cultures employed (Kongo, 2013). No significant differences in pH and titratable acidity were observed between samples DVS-C and DVS-B as well as their gross compositions (*P>0.05*). However, the DVS-K sample exhibited distinct acidity values from the others. Coincidentally Ozturkoglu-Budak et al. (2021)reported elevated acidity in quark cheese produced with kefir in alignment with the findings of this study. The water-soluble nitrogen (WSN) level in cheese served as an indicator of the cheese ripening degree. Notably, the DVSK sample had higher water-soluble nitrogen level and ripening index compared to the other samples. This observation can be attributed to the higher activity of LAB and yeasts in the DVSK starter culture, as supported by higher total bacteria counts in this sample. Similar findings were reported by Dimitrellou et al. (2010) that the level of proteolysis was high due to the presence of mixed microflora with high proteolytic activity in kefir.

Table 3. Change of pH, titration acidity (% lactic acid), water soluble nitrogen (WSN) and ripening index of quark cheese samples during storage (mean ± SE)

	Days	Samples			Average
		DVS-C	DVS-K	DVS-B	
pH (%)	1	4.16±0.03	4.09±0.15	4.27±0.02	4.14±0.11^{a}
	14	4.12±0.05	4.01±0.00	4.17±0.04	4.08±0.10^{a}
	28	4.04±0.01	3.95±.0.01	4.03±0.00	3.97±0.08^{b}
	Average	4.11±0.06^{A}	3.93±0.05^{B}	4.16±0.10^{A}	
Titratable (%) acidity	1	1.42±0.03	1.48±0.02	1.42±0.02	1.46±0.02
	14	1.45±0.00	1.54±0.04	1.45±0.02	1.48±0.04
	28	1.50±0.02	1.59±0.02	1.44±0.04	1.51±0.07
	Average	1.46±0.03^{B}	1.53±0.06^{A}	1.44±0.03^{B}	
WSN (%)	1	0.13±0.00	0.14±0.01	0.12±0.01	0.12±0.00^{b}
	14	0.14±0.01	0.15±0.00	0.13±0.02	0.13±0.00^{ab}
	28	0.15±0.01	0.16±0.01	0.15±0.01	0.14±0.00^{b}
	Average	0.13±0.00^{B}	0.15±0.00^{A}	0.13±0.01^{B}	
Ripening index (%)	1	7.52±0.00	8.40±0.13	7.09±0.3	7.67±0.58^{c}
	14	7.87±0.11	8.91±0.12	8.17±0.17	8.31±0.46^{b}
	28	8.34±0.10	9.54±0.03	8.58±0.24	8.82±0.54^{a}
	Average	7.90±0.34^{B}	8.95±0.47^{A}	7.94±0.67^{B}	

DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVS-B; cheese made using culture CH-N11.

The different lowercase letters in the same column indicate significant differences during the storage period (*P<0.05).*

The different upper case letters in the same row indicate significant differences among the samples (P<0.05)

Non-lettering columns indicates the differences among the average values are not found significant (P>0.05)

SE: Standard error

Table 4 presents water holding capacity (WHC) analysis results of the samples. The WHC of the DVS-K sample was consistently lower than that of the other samples, except on day 28. While the WHC values of both DVS-C and DVS-B samples decreased over the storage period, by the end of storage, they exhibited no significant difference from the WHC value of the DVSK sample. According to Diamantino et al. (2014) WHC is inversely related to syneresis, explaining why cheeses with higher moisture content tend to have lower WHC values. Hinrichs et al. (2004) additionally observed that an elevated total solids content enhances interactions between the serum phase and solids, leading to increased WHC. Given the DVS-K sample low dry matter and high moisture content (Table 2), it is expected that the WHC value would be lower than that of the other samples. Additionally, it is noteworthy that the presence of exopolysaccharides has an impact on WHC, and a reduction in syneresis has been reported in products fermented with EPS-producing cultures (Tiwari et al., 2021).

Table 4. Change of water holding capacity values of quark cheese samples during storage (mean ± SE)

	Days	DVS-C	DVS-K	DVS-B
Water holding capacity (%)	1	91.14±0.59^{AB}	84.25±0.63^{EF}	91.94±0.70^{A}
	14	90.66±0.60^{ABC}	84.00±0.78^{F}	90.42±0.70^{ABCD}
	28	87.81±0.60^{BCDE}	86.78±0.92^{DEF}	87.13±0.21^{CDEF}

DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVS-B; cheese made using culture CH-N11.

Different capital letters indicate differences between samples and storage days (*P<0.05*) SE: Standard error

Microbiological properties

TMAB, yeast-mold, *Lactococcus* and *Lactobacillus* counts of quark cheese samples are given in Table 5. The use of different starters in cheese production affected the TMAB count (*P <0.05*). Additionally, TMAB decreased over storage. *Lactococcus* spp. count was not affected by different cultures. However, number of *Lactococcus* ssp. decreased during the storage (*P<0.05*). Starter LAB added to milk during cheese production reached its maximum at the end of production. However, the number of starters gradually decreases due to adverse conditions such as salt concentration, low pH and temperature and lack of fermentable carbohydrates during storage (Blaya et al., 2018). Differences were observed in the number of lactobacilli in the samples depending on the variation of the culture used. Moreover, the number of *Lactobacillus ssp.* decreased over the storage period(*P<0.05*). All microbial counts of the DVS-K sample were higher than the others, a correlation supported by the corresponding physicochemical properties (refer to Table 3). These findings align with similar studies using kefir as a starter in cheese production (Dimitrellou et al., 2015; Kourkoutas et al., 2006). Yeast presence was exclusive to the DVS- K sample, potentially attributed to the yeasts inherent in the DVS-K culture. A previous study incorporating kefir grains in butter production similarly revealed elevated yeast levels, emphasizing their association with the characteristic yeasts present in kefir microflora (Karaca et al., 2018).

Table 5. Changes in microbial counts of quark cheese sample during storage (mean ± SE)

	Days	Samples			
		DVS-C	DVS-K	DVS-B	Average
TMAB (log CFU/g)	1	7.77±0.05	8.06±0.32	6.13±0.37	7.31±0.89 ^{a}
	14	6.70±0.08	6.84±0.12	5.17±0.14	6.23±0.76 ^{b}
	28	5.88±0.05	5.65±0.27	5.14±0.18	5.55±0.73 ^{b}
	Average	6.78±0.9^{A}	6.85±1.01 ^{A}	5.47±0.68 ^{B}	
*Lactococcus*ssp.	1	6.17±1.21	6.87±0.93	6.73±0.82	6,59±1.04 ^{a}
(log CFU/g)	14	5.24±1.26	6.77±0.18	5.07±0.19	5,69±1.06 ^{ab}
	28	4.80±1.24	5.34±0.36	3.76±0.29	4.63±1.00 ^{b}
	Average	5.41±1.36	6.33±0.91	5.19±1.32	
Lactobacillus ssp.	1	6.02±0.41	6.62±1.04	5.48±0.11	6.37±0.91 ^{a}
(log CFU/g)	14	5.19±0.18	6.43±0.15	3.85±0.77	5.49±1.25 ^{ab}
	28	5.57±0.44	5.26±0.23	2.78±0.13	4.54±1.28 ^{b}
	Average	6.26±0.69^{A}	6.10±0.86 ^{A}	4.03±1.2 ^{B}	
Yeast and mold	1	0.00±0.00	3.27±0.3	0.00±0.00	1.09±1.55
(log CFU/g)	14	0.00±0.00	3.25±0.37	0.00±0.00	1.08±1.54
	28	0.00±0.00	3.04±0.36	0.00±0.00	1.01±1.44
	Average	0.00±0.00 ^{B}	3.18±0.36 ^{A}	0.00±0.00 ^{B}	

DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVS-B; cheese made using culture CH-N11.

The different lowercase letters in the same column indicate significant differences during the storage period (*P<0.05).*

The different uppercase letters in the same row indicate significant differences among the samples (*P<0.05*).

Non-lettering columns and rows indicates the differences among the average values are not found significant *(P>0.05)*

SE: Standard error, TMAB: Total mesophilic aerobic bacteria

Colour properties of quark cheese

The L*, a* and b* values of quark cheese samples measured on the 1st, 14th, and 28th days of storage are given in Table 6. Colour stands out as a primary sensory attribute influencing consumer acceptance and purchase decisions. Numerous factors, including the colourof raw milk, production method, cheese ripening stage, and packaging technique, contribute significantly to the colour properties of cheese. The colour of

quark cheese is milky white to slightly yellowish (Chauhan et al., 2022).The utilization of different starters in quark cheese production revealed noteworthy variations in the colour properties of the cheeses. The L* value is an expression of the brightness, a significant difference in the L values of all samples was observed on day 1. Brightness value of the DVS-K sample was higher than the other samples on day 1. The L value decreased during storage in all samples. While positive and negative a* values indicate reddish and greenish colours, respectively, positive and negative b* values indicate yellowish and bluish colours, respectively (Pathare et al., 2013). a* value of the DVSC sample was different from the other samples. DVS-C sample had lower a* values than the rest of the samples. The b* value of the DVS-K sample was different from the other samples. This can be attributed to the lower fat and dry matter content of the DVS-K sample (Table 2). There was no difference in the b* value of DVS-C and DVS-B samples, except for day 14. Colour saturation or chroma (C values) indicates vividness or colour purity from the distance between the point and the origin. The longer this distance, the more vivid or saturated the colour (Ávila et al., 2008). High chroma value expressed a high human-perceived colour intensity of a sample (Pathare et al., 2013). As regards chroma values DVS-C and DVS-B samples presented more vivid colour than DVS-K samples. ΔE value (total colour difference) indicates the colour difference magnitude between the control and other samples. (Patras et al., 2011).

Perceptible differences in colour are classified as very distinct (ΔE>3), distinct (1.5<ΔE<3), and slightly different (1.5<ΔE). Therefore, the difference between samples is not perceptible because the ΔE value is less than 1.5.

Table 6. Colour, ΔE and chroma (C) values of quark cheese samples (mean ± SE)

	Days	Samples		
		DVS-C	DVS-K	DVS-B
L*	1	88.35 ± 0.03^{BCD}	88.74 ± 0.2^{A}	87.45 ± 0.4^{F}
	14	88.29 ± 0.02^{CDE}	88.41 ± 0.03^{BC}	88.27 ± 0.03^{DE}
	28	88.30 ± 0.2^{BCDE}	88.43 ± 0.3^{B}	88.18 ± 0.05^{E}
a*	1	-2.67 ± 0.5^{C}	-2.47 ± 0.03^{AB}	-2.34 ± 0.02^{A}
	14	-2.89 ± 0.2^{D}	-2.60 ± 0.05^{BC}	-2.43 ± 0.03^{A}
	28	-2.62 ± 0.02^{C}	-2.42 ± 0.02^{A}	-2.46 ± 0.2^{A}
b*	1	12.72 ± 0.03^{AB}	12.01 ± 0.05^{F}	12.76 ± 0.6^{AB}
	14	12.78 ± 0.16^{A}	12.22 ± 0.03^{E}	12.51 ± 0.12^{C}
	28	12.67 ± 0.14^{AB}	12.36 ± 0.01^{D}	12.64 ± 0.14^{BC}
ΔE	1	0.00 ± 0.0^{G}	0.83 ± 0.00^{B}	0.95 ± 0.00^{A}
	14	0.00 ± 0.0^{G}	0.64 ± 0.01^{C}	0.53 ± 0.01^{D}
	28	0.00 ± 0.0^{G}	0.39 ± 0.00^{E}	0.20 ± 0.00^{F}
C	1	12.99 ± 0.03^{AB}	12.26 ± 0.3^{F}	12.97 ± 0.4^{AB}
	14	13.10 ± 0.2^{A}	12.49 ± 0.5^{E}	12.74 ± 0.5^{CD}
	28	12.94 ± 0.02^{B}	12.59 ± 0.6^{DE}	12.87 ± 0.4^{BC}

DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVSB; cheese made using culture CH-N11.

Different uppercase letters show the significant differences among the samples and storage days for each property (*P<0.05*). SE: Standard error

SDS-PAGE Electrophoresis

Figure 1 shows the SDS-PAGE electrophoretic separation of the cheese samples. Although there was a difference in the WSN results according to Table 3, this difference was not related to caseins. There were no remarkable differences between the cheeses in terms of β-casein and α_s-casein degradation levels. However, a slight time-dependent degradation of both β-casein and αs-casein degradation was obvious. It has been

reported that α-lactalbumin and βlactoglobulin are resistant to proteases in semi-hard and ultrafiltered cheeses (Grappin et al., 1985). Therefore, it is expected that these proteins will remain stable throughout the storage period in fresh cheeses. Besides, a high degree of proteolysis is not expected in fresh cheese such as quark. Furthermore, while the proteolytic activity of cheese starters can vary depending on the strain, it is recognized that many commercial starter strains employed in fresh dairy products exhibit weak to moderate proteolytic activity (Akal et al., 2022).

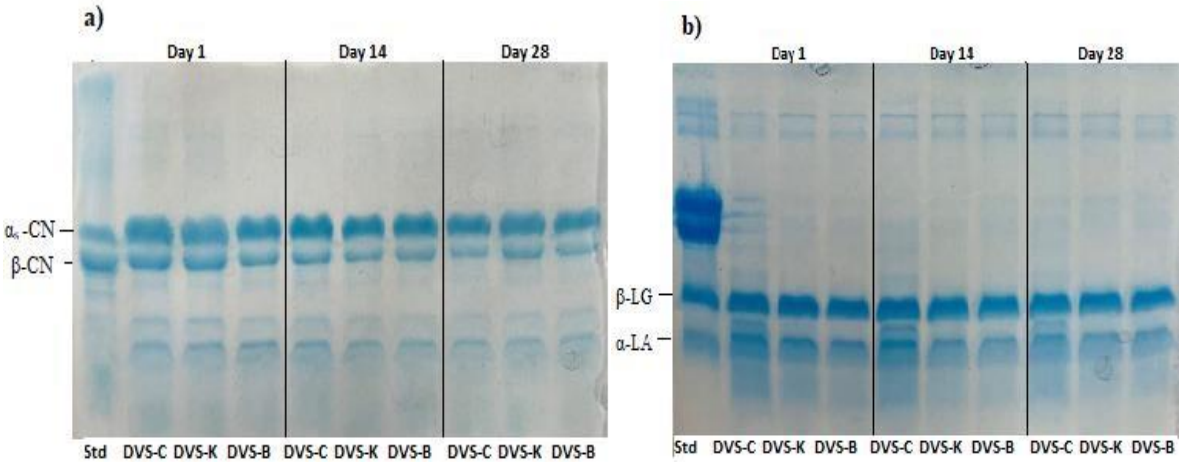

Figure 1. Electrophoretograms of casein (a) and whey protein (b) fractions of quark cheeses. DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVS-B; cheese made using culture CH-N11. Std; sodium-caseinate, CN: casein, Lg: lactoglobulin, La: lactalbumin

Textural and spreadability properties

Table 7 shows texture and spreadability properties of quark cheese samples. The textural properties of fresh cultured products are more related to raw material quality, production technology (such as heat treatment, starter culture, homogenization, incubation) and postproduction processing and storage conditions (Fox et al., 2016). Firmness is defined as the force required to compress the cheese between the fingers and is a measurement of the peak force applied to the product during testing. It was found that the DVS-K sample was significantly different from the others in terms of all textural and spreadability properties on day 1 ($P<0.05$). The firmness value of the DVS-K was lower than the other samples. Quark cheese made using cultures CH N11 (DVS-B) and R-703 (DVS-C) had lower moisture and higher total solid contents, which might explain the higher resistance to deformation compared with the quark cheese made from using kefir cultures. Changes in fat and moisture content of cheese directly affect firmness and spreadability properties. Stickiness is the degree of adhesion of the product to the tongue and palate during chewing. The more negative the value, the stickier the product. DVS-C and DVS-B samples were stickier than the DVS-K sample. Spreadability is expressed as a measure of how easily and uniformly a product can be deformed and spread over the surface of the layer (Mirela Lučan et al., 2020). Work of shear defines the force required to spread the product on a surface (e.g., bread) and expresses the opposite of the ability to be spreadable. A higher value in this context indicates reduced spreadability of the product. Samples with lower firmness were expected to require a lower work of shear to spread, and indeed the DVS-K sample confirmed this. Work of adhesion is expressed as the area of the negative peak during the return of the upper probe to the origin. The work of adhesion value of the DVS-K sample was lower from the other samples on day 1. The use of kefir culture in the production of quark cheese affected the spreadability properties of the cheese positively,

but it caused a weakening in the texture of the cheese. This phenomenon could be attributed to the generation of exopolysaccharides by kefir microflora in the sample DVS-K.A parallel study noted that cheeses crafted from an EPS a smoother, creamier, moremoist, and softer consistency, attributed to the water retention properties of EPS (Ahmed et al., 2005).

Table 7. Textural and spreadability analysis of quark cheese samples (mean ± SE)

	Days	Samples		
		DVS-C	DVS-K	DVS-B
Firmness (g)	1	569.88±38.62^{A}	271.37±9.22^{CD}	560.41±46.76^{A}
	14	383.39±15.69^{BC}	228.15±8.22^{CD}	371.26±0.55^{BC}
	28	483.26±4.77^{AB}	383.35±35.61^{BC}	464.06±1.92^{AB}
Stickiness (g.sec)	1	-143.70±9.31^{A}	-79.76±2.28^{CD}	-139.52±14.18^{AB}
	14	-94.37±0.49^{CD}	-63.34±4.29^{D}	-92.60±1.45^{CD}
	28	-113.14±0.41^{ABC}	-105.09±10.50^{ABC}	-103.54±2.73^{BC}
Work of Shear (g)	1	1188.79±72.51^{A}	552.79±17.62^{C}	1187.25±129.73^{A}
	14	786.87±35.44^{BC}	460.79±10.09^{C}	753.89±16.51^{BC}
	28	965.47±45.07^{AB}	795.00±73.64^{BC}	919.60±42.81^{AB}
Work of Adhesion (g.sec)	1	-88.95±8.15^{A}	-56.51±1.48^{C}	-79.33±7.97^{AB}
	14	-55.10±1.76^{C}	-45.31±3.85^{C}	-56.17±0.59^{C}
	28	-65.34±3.03^{ABC}	-68.69±7.90^{ABC}	-61.40±0.18^{ABC}

DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVSB; cheese made using culture CH-N11.

Different uppercase letters show significant differences among the samples and storage days for each property (*P<0.05*)

SE: Standard error

Sensory properties

Figure 2. shows the results of sensorial attributes of quark cheese samples.DVS-K sample was significantly different from the others in terms of body and texture (*P<0.05*). Regarding bodytexture properties, DVS-K sample had high scores than the other samples. The taste-flavor of DVS-K sample were higher than the other samples on day 1 and 14. Panelists also noted that DVS-K cheese had a pleasant, refreshing, and slightly acidic taste. It is probably due to the yeast population responsible for flavor-aroma of kefir. Yeasts in kefir culture contribute to taste and aroma by producing alcohol and carbon dioxide, and kefir used as a starter culture in cheese manufacturing, it has a positive effect on the taste, aroma and structure of cheese (Bengoa et al., 2019; Nielsen et al., 2014). In a previous study, distinctions between traditional and probiotic cultures in quark cheese production were uncovered, leading to the conclusion that the utilization of a probiotic culture had a positive influence on the sensory properties of quark cheese (Duric et al., 2007). However, DVS-K had the lowest taste and aroma score at the end of storage. It may be due to the DVS-K samples acidity increased too much at the end of the storage. There was no difference between the samples in terms of colour and appearance during storage (*P>0.05*).

CONCLUSIONS

The results of the present study clearly showed that the use of kefir starter culture in the manufacture of quark cheese influenced its physicochemical, textural and sensorial properties. There was a change in gross composition of the cheese using DVS-K culture. The fat, dry matter and protein amount was lower than the other samples. The actual yield increased, but the dry matter yield decreased in DVS-K sample. The results indicated that DVS-K cultures slightly increased the rate of proteolysis in quark cheeses. Use of different culture did not

affect colour and appearance. According to sensory results, the DVS-K sample was the most liked sample regarding taste and flavor. However, it was the least preferred sample due to the high acidity at the end of storage. This may negative affect the shelf life of the DVS-K sample. The use of kefir culture positively affected the spreadability of the cheese. No significant differences were found between DVS-C and DVS-B samples regarding physicochemical, textural and microbiological properties, and the DVS-B sample scored the lowest in taste and flavor. These results have shown that quark cheese with better spreadable and sensory properties can be obtained by using kefir culture to improve the aroma and texture in the production of quark cheese.

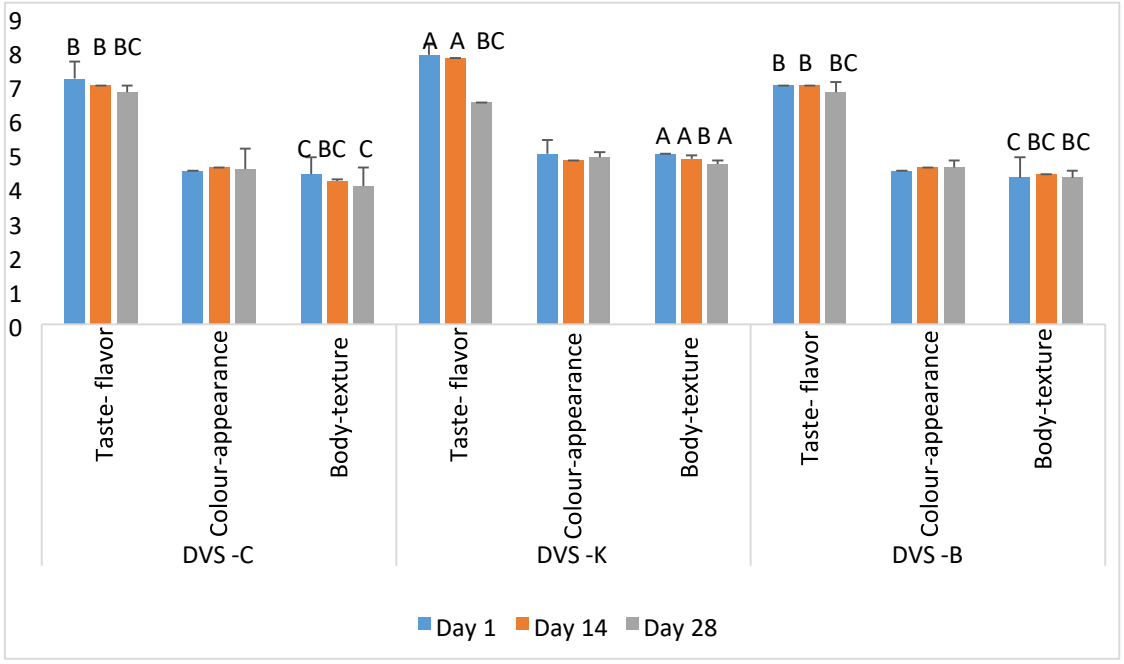

Figure 2. Sensorial attiributes of quark cheese samples.
DVS-C; cheese made using culture R-703, DVS-K; cheese made using culture Kefir DC-1 and DVSB; cheese made using culture CH-N11.
Non-lettering graphs indicates the differences among the values are not found significant (*P>0.05*)
Different uppercase letters indicate that the difference among the samples is significant (*P<0.05*)

CONFLICT OF INTEREST

The author has no financial or proprietary interests in any material discussed in this article.

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