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Microbiological, physicochemical and sensory characteristics of traditional white soft cheese (*Gibna bayda*) supplemented with commercial starter culture

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Abstract

This study was conducted to investigate the effect of starter culture addition on the characteristics of raw milk white cheese (*Gibna bayda*).The cheese was made from raw warmed (45°C) milk, and the starter culture (2% w/v) was added to the first treatment (T1), while no starter culture was added to the second treatment (T2). After the manufacture, cheese was cut into cubes and kept in the brine solution (2% w/v) for 24 hours, followed by storing without whey at 5°C for 45 days. Microbiological, physicochemical, and sensory characteristics were evaluated at 1, 15, 30, and 45-day intervals. Results showed that total viable bacteria [TVB] (log_{10} 6.73 cfu/gm), *Staphylococcus aureus* (log_{10} 2.15 cfu/gm), *Escherichia coli* (log_{10} 1.11 cfu/gm) and yeasts and moulds (log_{10} 6.21 cfu/gm) counts were high in T2 cheese. TVB significantly decreased during the ripening period, while the other microorganisms increased. Fat (25.28%) and total solids (44.27%) were high in T1, while protein (18.44%), moisture (55.77), ash (6.51%), and acidity (0.59%) were high in T2. All physicochemical characteristics except fat were significantly influenced by the ripening period. Taste and body scored best in T1, while the rest of the sensory attributes scored best in T2. All sensory properties were significantly affected by the ripening period except the colour. The study concluded that the use of the starter culture improved the microbiological quality and sensory properties of traditional Sudanese white cheese, which might make this starter culture suitable for this type of cheese.

Keywords: Raw milk; Physicochemical; Microbiological; Sensory; Ripening period; Starter culture.

1. Introduction

Cheese is considered a dairy product in which casein, fats, and other milk nutritional compounds remain in the curd, and it provides proteins, carbohydrates, fats, and inorganic ions among other nutrients [1]. The principal objective of cheese production is to keep the nutrient compounds in non-spoiling conditions without losing the desired flavour [2]. Starter cultures are one or more types of lactic acid bacteria that are added to raw or pasteurized milk to produce fermented dairy products [3]. Lactic acid bacteria (LAB) are a heterogeneous group of bacteria that plays an essential role in numerous fermentation processes. LAB ferment food carbohydrates to produce lactic acid, which is the fundamental product of the fermentation process. LAB consist of four genera; *Leuconostoc*, *Lactobacillus*, *Streptococcus,* and *Pediococcus* [4]. The current taxonomic reviews have proposed numerous new genera that include; *Aerococcus*, *Carnobacterium*, *Alloiococcus*, *Enterococcus*, *Dolosigranulum*, *Lactococcus*, *Globicatella*, *Tetragenococcus*, *Vagococcus*, *Oenococcus*, and *Weissella*. The importance of these genera is mainly due to their safe metabolic activity while growing in foods [4].Fermentation with lactic acid bacteria is the economic and effective preservation technique that can be applied even in more rural places and leads to improvement in flavour, texture, and nutritional value of various food products [5]. The use of starter cultures containing thermophilic/mesophilic lactic acid bacteria is an essential

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requirement for cheeses, with their major function being the production of lactic acid and flavour compounds, and in producing different types of cheeses according to taste, aroma, and texture, different types of microorganisms are used [6]. Lactic acid bacteria, generally recognized as safe (GRAS), are apprehended as appropriate to be used as natural preservatives in food to control fungal growth and subsequent mycotoxin production [7]. Besides, certain LAB have been found to produce bacteriocins that can have a bacteriostatic or bactericidal effect on pathogenic bacteria [4].

For artisanal cheese, the back-slopping technique has traditionally been used, which requires the inoculation of milk with whey or fermentate. Additional hard work in controlling starter quality has led to defined starter cultures, consisting of a specific number of strains of bacteria that have been isolated from undefined starter cultures [8]. The application of defined starter culture combinations and rotation aims to guarantee the consistency of the fermentation process [9]. The possibility of improving the quality of traditional Sudanese white cheese (*Gibna bayda*), specifically by the use of defined starter cultures needs to be assessed.

This study is conducted to evaluate the effect of commercial starter culture addition on the characteristics of raw milk white cheese (*Gibna bayda*) during the ripening period.

2. Material and methods

2.1. Materials

Full-fat raw cow's milk was purchased from Sudan University of Science and Technology farm, Khartoum North, Sudan. Direct Vat Set starter culture (*Streptococcus thermophilus and Lactobacillus delbrueckii subsp. bulgaricus*, 1:1 combination) and rennet powder were purchased from Chris Hansen's Laboratory (Denmark). The table salt (sodium chloride) was obtained from the local market.

2.2. Cheese manufacture

The cheese was manufactured according to the method of Salih and Abdalla [10] with some modifications. Fourteen liters of full fat cow's milk was warmed to 45°C and 2% (w/w) of the sodium chloride was added. Then, the milk was transferred into two stainless steel vats (7 L in each), followed by cooling to 42°C. The starter culture (2% w/v) was added to the first treatment (T1), while no starter culture was added to the second treatment (T2). The milk was left for 30 min to develop acidity, then the chymosin powder (1.3 gm/50 L milk) was dissolved in 50 ml distilled water before addition to both treatments (T1 and T2) at 40°C. Then, the milk was stirred for 20 min and left undisturbed to develop a curd, which later was cut into small cubes (2.5 × 2.5 × 2 cm) using a sterile stainless-steel knife and left in whey for at least 10-15 min. The curd was then poured into small wooden molds lined with cheese cloth and pressed overnight (1 kg weight). On the next day, a brine solution was prepared by adding 2% (w/v) of the salt to the collected whey, pasteurized at 72°C/1 min, and cooled to 40°C. The curd was preserved in the prepared brine solution for 24 hr. Then, the cheeses were packed into plastic containers (100gm) and stored without whey at 5°C for 45 days. The microbiological, physicochemical, and sensory characteristics of the experimental cheeses were evaluated at 1, 15, 30, and 45-day intervals. The manufacture of cheese was performed in triplicate.

2.3. Microbiological examination of cheese

2.3.1. Preparation of samples

To prepare the cheese sample for microbial analysis, eleven grams of the cheese sample was weighed aseptically in a sterile mixer, then 99 ml of sterile peptone water were added, and mixed for two minutes to make the first dilution (10^{-1}). A tenfold dilution was prepared up to 10^{-8} using sterile peptone water [11].

2.3.2. Total viable bacterial count (TVBC)

Plate count agar medium (Himedia, M091) was used for TVBC enumeration. The Petri dishes were incubated in an inverted position at 37°C for 48 hours, and then colonies were counted using a manual colony counter (scan 100) and the total number of viable bacteria was counted as cfu/gm [12].

2.3.3. Staphylococcus aureus count

For the enumeration of coagulase-positive staphylococci, Mannitol salt agar (Micro master, DM160) was used. The Petri dishes were incubated in an inverted position at 37°C for 48 hours, and then colonies were counted using a manual colony counter (scan 100) and recorded as cfu/gm [11].

2.3.4. Escherichia coli count

Peptone water (Himedia, M028) and Brilliant green lactose bile (BGB) broth (Merck, 736) were used for the enumeration of *E. coli* using the most probable number technique. Eosin methylene blue (EMB) agar (Millipore, 70186) was used for the confirmation of the presence of *E. coli*. Then, the conventional biochemical tests were used for further characterization of the isolates [13].

2.3.5. Yeasts and moulds count

Yeast extract agar medium (Himedia, M456) was used for the enumeration of yeasts and moulds. The Petri dishes were incubated in an inverted position at 25°C for 5 days, and then colonies were counted using a manual colony counter (Scan 100) and documented as cfu/gm [14].

2.4. Physicochemical analysis of milk and cheese

The fat, protein, total solids, ash contents, and titratable acidity of cheese were determined according to AOAC [15], while the moisture content was determined by subtraction (100% - total solids%).

2.5. Sensory evaluation of cheese

Before sensory testing, the cheese samples were left at room temperature for two hours. After that cheese samples were presented in white plastic trays for evaluation. A panel consisting of ten untrained panelists of age 20-30 years (6 females and 4 males) accustomed to the product were selected and asked to evaluate the quality of the cheeses (flavour, colour, taste, saltiness, body, and overall acceptability) by using an evaluation sheet, where flavour 1= bland to 4= extremely intense; colour 1= unacceptable to 4= acceptable; taste 1= absent to 4= excessive acid; saltiness 1= moderate to 4= too salty; body 1= smooth to 4= pasty; overall acceptability 1= unacceptable to 4= acceptable [16].

2.6. Statistical analysis

Statistical analyses were conducted using the Statistical Analysis Systems (SAS, ver. 9). To determine the influence of the starter culture on the microbiological, physicochemical, and sensory characteristics of raw milk Sudanese white cheese during the ripening period a factorial design (2 × 4) was used. Duncan's multiple range test was conducted for mean separation between treatments ($P \leq 0.05$).

3. Results and discussion

3.1. Effect of starter culture on the microbiological characteristics of cheese

The results in Table 1 present the microbiological quality ($\log_{10}$ cfu/gm) of white cheese as influenced by starter culture addition. *E. coli* and yeasts and moulds counts were significantly influenced by the starter culture addition, while total viable bacteria and *S. aureus* counts were not ($P > 0.05$). The result of TVBC is in disagreement with previous studies which indicated that the total viable bacterial count was significantly ($P < 0.01$) influenced by the addition of starter culture, being highest (4.1×10^6cfu/gm) in cheese made with starter culture and lowest (2.3×10^4cfu/gm) in cheese manufactured without a starter culture [17]. This result might be due to the use of non-pasteurized milk in control cheese production. *E. coli* is used as an indicator microorganism, and the presence of *E. coli* indicates a risk that other enteric pathogens may be existing in the product. *E. coli* was not detected in T1 cheese, while the count was low ($\log_{10}$ 1.11cfu/gm) in T2 cheese. The starter culture was found to have a notable effect on reducing the pathogenic organisms by souring milk [18]. The result of *S. aureus* count is in agreement with Salih and Abdalla [10] who stated that the *S. aureus* count in cheese made using the starter culture was lower than in cheese produced without using the starter culture. The reduction in *E. coli* and *S. aureus* counts may be due to inhibitory activities of the starter culture against pathogenic microorganisms, such as the production of organic acids and lowering the pH, as well as the starter cultures, acts as a competitor to nutrients such as biotin and nicotinamide [10, 19]. Centre for Food Safety (SFC) [20] reported that the number of entrances of pickled cheeses can be accepted in the range of 10^2-10^4cfu/gm. The result of yeasts and moulds count is in agreement with that of Salih and Abdalla [10] who found that the moulds and yeasts count was significantly ($P < 0.001$) influenced by the starter culture addition and this result mainly due to antifungal activities of lactic acid bacteria [4, 7].

Table 1 Effect of starter addition culture on the microbiological characteristics (log_{10} cfu/gm) of raw milk cheese.

Microbiological characteristics	Treatment		SE	SL
	T1	T2		
TVB	6.64[a]	6.73[a]	0.015	NS
S. aureus	1.88[a]	2.15[a]	0.162	NS
E. coli	ND	1.11[a]	0.382	**
Yeasts and moulds	5.53[b]	6.21[a]	0.037	***

Means in each row bearing different superscripts are significantly different (P<0.05). ***= P<0.001; **= P<0.01; NS= Not significant; ND=Not detected; SE = Standard error of means; SL= Significance level; T1=the cheese made with starter culture addition; T2=the cheese made without starter culture addition

3.2. Microbiological characteristics of cheese during the ripening period

The results in Table 2 show that TVBC significantly (P<0.001) decreased from log_{10} 7.08 cfu/gm on day 1 to log_{10} 6.35cfu/gm on day 15, before gradually increasing toward the end (log_{10} 6.89cfu/gm). The decrease in TVBC as the ripening period progressed was consistent with previous report showing an insignificant decrease in the total viable bacterial count of white cheese during the ripening period of 60 days [21] and in disagreement with Abdalla and Omer [22] who outlined that the total viable bacteria count increased during the processing of white cheese by traditional methods from log_{10} 7.68 cfu/gm in raw milk to log_{10} 7.91 cfu/gm in milk delivered to the market. The increasing trend agrees with the findings of Abdalla and Mohammed [23] who reported that a minor increase in total viable bacterial count (TVBC) was observed at the end of the ripening period. This result can be due to the change in environmental conditions throughout the ripening period, which allowed the multiplication of microorganisms [10].

Table 2 Microbiological characteristics (log_{10} cfu/gm) of raw milk cheese made with starter during the ripening period.

Microbiological characteristics	Ripening period (days)				SE	SL
	1	15	30	45		
TVB	7.08[a]	6.35[b]	6.40[b]	6.89[a]	0.024	***
S. aureus	2.62[a]	0.37[b]	2.32[a]	2.75[a]	0.057	***
E. coli	ND	0.72[b]	ND	1.51[a]	0.093	*
Yeasts and moulds	5.31[b]	5.92[a]	6.15[a]	6.09[a]	0.032	***

Means in each row bearing different superscripts are significantly different (P<0.05); ***=P<0.001; *=P<0.05; SE=Standard error of means; SL=Significance level

S. aureus counts significantly (P<0.001) increased during the ripening period from log_{10} 2.62 cfu/gm on day 1 to log_{10} 2.75 cfu/gm on day 45. These findings disagree with those of Abdalla and Omer [22] who reported a decreasing trend of *S. aureus* during the processing of white cheese by traditional methods and in line with Al-Ghamdi et al. [21] who reported that *S. aureus* insignificantly increased during the ripening period of white cheese for 60 days. Kheir et al. [24] reported that *S. aureus* fluctuated during the ripening period of white cheese made with rennet without starter culture reaching the maximum count of 9.02×10^4cfu/gm on day 60. *S. aureus* bacteria are able to multiply rapidly, particularly during the preliminary phase of preparation when spontaneous lactic acid bacteria are in the lag phase and no adequate amount of lactic acid has been formed before significantly reduced in acidic conditions [10].

E. coli was not noticed on days 1 and 30, showing the lowest count on day 15 (log_{10} 0.72 cfu/gm) and the highest count on day 45 (log_{10} 1.51cfu/gm). These results are not in line with the finding of ElOwni and Hamid [25] who found that *E. coli* count progressively decreased during the ripening period of white cheese from log_{10} 2.14±0.16 cfu/gm on day 0 to log_{10} 0.16±0.43 cfu/gm on day 120 and not detected after that. In a previous study, *E. coli* was not noticed at days 1 and 30 of the ripening period of cheese made with a starter culture [10].

Yeasts and moulds count increased from log_{10} 5.31 cfu/gm at the beginning to log_{10} 6.09 cfu/gm at the end of the ripening period. Previous studies reported that yeasts and moulds increased during the ripening period of white cheese

[21, 23, 25, 26]. The increase in yeasts and moulds counts throughout the ripening period might be because yeasts and moulds can metabolize lactic acid at a lower pH [10].

3.3. Effect of starter culture on the physicochemical characteristics of cheese

The results in Table 3 present the physicochemical characteristics of white cheese made with and without starter culture. All physicochemical characteristics were not significantly (P>0.05) affected by starter culture addition and this result agrees with that of Evangelia et al. [27] who reported that the starter culture addition in cheese showed no significant variation in the composition. The result of fat content is in agreement with Salih and Abdalla [10] who stated that the fat content of cheese was not affected by the starter culture addition and this result might be due to a minor contribution of lactic acid bacteria to the lipolysis process in fermented dairy products [4]. The protein content was not significantly (P>0.05) influenced by the addition of starter culture, but the higher protein content (18.44%) was observed in cheese that made without starter culture addition and this result is in accordance with the finding of Sert et al.[28] who reported that proteolysis was greater in conventional cheeses produced without starter addition than in those produced by adding a starter culture, but this difference was not significant.

Table 3 Effect of starter culture addition on the physicochemical characteristics of raw milk white cheese

Physiochemical Characteristics (%)	Treatment		SE	SL
	T1	T2		
Fat	25.28[a]	24.86[a]	0.544	NS
Protein	18.21[a]	18.44[a]	0.662	NS
Total solids	44.27[a]	44.23[a]	0.819	NS
Moisture	55.69[a]	55.77[a]	0.821	NS
Ash	6.39[a]	6.51[a]	0.260	NS
Acidity	0.55[a]	0.59[a]	0.041	NS

Means in each row bearing different superscripts are significantly different (P<0.05); NS=Not significant; SE=Standard error of means; SL=Significance level; T1=The cheese made with starter culture addition; T2=The cheese made without starter culture addition

This difference could be explained by the use of non-pasteurized milk in traditional cheese production, as total aerobic mesophilic bacteria, total psychotropic bacteria, and moulds and yeasts counts in traditional cheese were higher than in the starter culture-added cheese. Also is in accordance with that of Mudawi et al. [17] who reported that as the concentration of the starter culture added to milk for white cheese manufacture increased from 0% to 2.5%, the protein content decreased and is not in line with Hussein and Shalaby [29] who reported that cheese made using yogurt starter culture shows an increase in protein content. Although the total solids and moisture contents were not significantly (P>0.05) affected by the addition of starter culture, total solids (44.27%) content was high in T1 cheese, while the moisture (55.77%) content was high in T2 cheese. These results are in accordance with those of Shabbir et al. [30] who reported that the use of starter culture resulted in higher titratable acidity in cheese, which improved the whey separation led to an increase in total solids content.

3.4. Physicochemical characteristics of cheese during the ripening period

The results in Table 4 present the effect of the ripening period on the physicochemical characteristics of raw milk white cheese made with a starter culture. The fat insignificantly increased from 23.75% on day 1 to a maximum on day 15 (25.97%) before decreasing to 25.09% at the end of the ripening period. Generally, fat content increased with the progress of the ripening period. This result is in agreement with the findings of Salih and Abdalla [10] who reported an increasing trend of fat content during the ripening period of pasteurized milk-white cheese made with the addition of starter culture, and Kheir et al. [24] who reported an increasing trend in the fat content of white cheese manufactured from heated milk without the addition of starter culture. However, the result is in disagreement with Omer and Abdalla [31] who reported a decrease in the fat content of white cheese made by traditional methods from 6.68% in cheese after pressing to 11.27% in cheese delivered to the market. The increase in fat content at the beginning of the ripening period is probably due to high moisture loss during ripening [32].

Table 4 Physicochemical characteristics of raw milk cheese made with starter culture during the ripening period

Physiochemical characteristics (%)	Ripening period (days)				SE	SL
	1	15	30	45		
Fat	23.75[a]	25.97[a]	25.47[a]	25.09[a]	0.192	NS
Protein	22.18[a]	18.18[b]	17.06[b]	15.91[b]	0.234	***
Total solids	35.53[b]	47.46[a]	47.83[a]	46.20[a]	0.289	***
Moisture	64.48[a]	52.54[b]	52.12[b]	53.80[b]	0.290	***
Ash	8.71[a]	5.66[b]	5.71[b]	5.73[b]	0.092	***
Acidity	0.22[c]	0.57[b]	0.75[a]	0.73[a]	0.015	***

Means in each row bearing different superscripts are significantly different (P<0.05); *** =P<0.001; NS =Not significant; SE=Standard error of means; SL=Significance level

The protein content significantly (*P*<0.001) decreased from 22.18% on day 1 to 15.91% on day 45. This result is in agreement with Salih and Abdalla [10] who concluded that the protein content of pasteurized milk-white cheese made with and without starter culture significantly increased during the ripening period. However, the results disagree with the findings of Kheir et al. [24] who found an increasing trend of the protein content of white cheese made from pasteurized milk using both rennet and *Solanum dubium* as coagulants without the addition of starter culture. The decrease in the protein content during the ripening could be attributed to protein degradation leading to the formation of water-soluble compounds [32].

Total solids content significantly (*P*<0.001) increased from 35.53% on day 1 to 47.83% on day 30, before decreasing to 46.20% on day 45. A previous study reported an increase in total solids of pasteurized milk-white cheese made with and without the addition of starter culture during the ripening period of 45 days [10]. The increase in total solids content may be due to a decrease in the moisture content because of lactic acid developments that caused curd contraction [32]. The moisture content gradually decreased from 64.48% at the beginning of the ripening period to 53.80% at the end. These results are in agreement with Salih and Abdalla [10] who reported that the moisture content of pasteurized milk cheese made with and without starter culture decreased during the ripening period and in disagreement with El Siddig et al. [26] who reported an increasing trend of moisture content of white cheese during the ripening period of four months. The ash content significantly (*P*<0.001) decreased from 8.71% on day 1 to 5.73% on day 45. Similar results were reported [10, 32].

The acidity showed an increase with the progress of the ripening period from 0.22% at the beginning to 0.73% at the end. The increase in the acidity during the ripening period may be attributed to the development of acidity in cheese because of the action of lactic acid bacteria [10, 24, 26, 32].

3.5. Effect of starter culture on the sensory characteristics of cheese

Table 5 presents the sensory characteristics of white cheese as affected by starter culture addition. The colour of cheese was not significantly affected by the starter culture addition, although T2 cheese scored better (3.30) than T1 cheese. The flavour (2.70) and overall acceptability (3.20) were better in T2 cheese, compared to T1 cheese, while T1 cheese was better in taste (2.43) and body (2.26) and slightly tasted salty (1.44) than T2 cheese. The result of taste is in agreement with that of Salih and Abdalla [10] who found that cheese made with starter culture demonstrated a higher score of taste compared to the cheese made without a starter culture. The result of the body is in agreement with Sulejmani et al. [33] who found that Feta cheese made with starter culture exposed a better texture, because of the activity of lactic acid bacteria that contribute to the development of acidic conditions, facilitating the activity of rennet enzyme. Also, in agreement with Mailam et al. [34] who found that the higher fat content of the cheese made with EPS-producing cultures changed its sensory attributes, providing a softer texture for the product. The result of flavour agrees with that of Susanto [35] who found that cheese without starter culture showed a higher concentration of volatile compounds compared to other cheeses, and this result proves that nonstarter lactic acid bacteria (NSLAB) in general cause a higher rate of lipolysis than starter lactic acid bacteria (SLAB), although other microorganisms, such as yeasts and molds also supposed to play an important role to the lipolysis. Also, this result is in accordance with that of Mailam et al. [34] who found that cheeses made with EPS-producing culture received lower flavour scores than the control throughout ripening. The result of the overall acceptability is in agreement with Frau et al. [36] who found that cheese made with commercial starter had a lower score in general acceptance due to its highly acidic taste.

Table 5 Effect of starter culture addition on the sensory characteristics of raw milk cheese

Sensory characteristics	Treatment		SE	SL
	T1	T2		
Colour	3.16[a]	3.30[a]	0.037	NS
Flavour	2.53[b]	2.70[a]	0.039	*
Taste	2.43[b]	2.08[a]	0.031	***
Body	2.26[a]	1.85[b]	0.030	***
Saltiness	1.44[a]	1.28[b]	0.019	**
Overall acceptability	2.79[a]	3.20[b]	0.046	***

Means in each row bearing different superscripts are significantly different (P<0.05); ***=P<0.001; ** =P<0.01; *=P<0.05; NS=Not significant; SE=Standard error of means; SL=Significance level; T1=the cheese made with starter culture addition; T2=the cheese made without starter culture addition

3.6. The sensory characteristics of cheese during the ripening period

Table 6 presents the effect of the ripening period on the sensory characteristics of cheese. Except for the colour of cheese, all sensory attributes were improved as the ripening period progressed. The colour of cheese insignificantly improved to a score of 3.41 on day 30 before deteriorating to a score of 3.09 on day 45. These results agree with those of Mohammed and Abdalla [37] who reported that the colour of cooked and uncooked white cheese improved until day 40 of the ripening period then deteriorated after that, and do not agree with the findings of ElOwni and Hamid [25] who indicated that the colour of white cheese deteriorated during the ripening period of 240 days. Dhuol and Hamid [38] reported that the colour of Sudanese white soft cheese made from cassava powder deteriorated during the ripening period of 90 days.

Table 6 Sensory characteristics of raw milk cheese made with starter culture during the ripening period

Sensory Characteristics	Ripening period (days)				SE	SL
	1	15	30	45		
Colour	3.23[a]	3.19[a]	3.41[a]	3.09[a]	0.009	NS
Flavour	2.45[b]	2.38[b]	2.70[a]	2.93[a]	0.009	***
Taste	1.90[c]	2.31[b]	2.20[b]	2.59[a]	0.008	***
Body	1.43[b]	2.30[a]	2.19[a]	2.31[a]	0.010	***
Saltiness	1.10[d]	1.65[a]	1.26[c]	1.43[b]	0.006	***
Overall acceptability	2.83[b]	3.15[a]	3.08[ab]	2.94[ab]	0.009	*

Means in each row bearing different superscripts are significantly different (P<0.05); *=P<0.05; ***=P<0.001; NS=Not significant; SE=Standard error of means; SL=Significance level

The flavour of cheese progressively improved from 2.45 on day 1 to 2.93 at the end. These results agree with the findings of Salih and Abdalla [10] who reported that the flavour of pasteurized milk-white cheese made with and without starter culture improved during the ripening period of 45 days and in disagreement with the results of Elmahi and ElZubeir [39]. The improvement of flavour could be due to the development of lactic acid either from natural flora in the raw milk or the starter culture added to the milk before cheese making, which resulted in the suppression of undesirable microorganisms [25].

The taste score increased significantly (P<0.001) from 1.90 on day 1 to 2.59 on day 45. This result is in disagreement with Hamid [32] who observed a decreasing trend in the taste score of white cheese during the ripening period and Abdalla and Yahya [40] who revealed that the taste of white cheese significantly deteriorated during the ripening period reaching the lowest score at the end of 30-day ripening. This result is in accordance with that of Abdalla and Mohammed [23] who found that the taste score of cooked and uncooked white cheese increased during the ripening period of 60 days. This increase may be the result of a complex series of biochemical, and chemical activities caused by several factors like starter culture, residual coagulants, and nonstarter microflora [10].

The body score increased from 1.43 at the beginning of the ripening period to 2.31 at the end. Similar results were stated by Salih and Abdalla [10] for pasteurized milk-white cheese during the ripening period of 45 days and Elmahi and ElZubeir [39]. The improvement in cheese structure during the ripening period may be the result of lactic acid production [10]. As the ripening period progressed, the cheese became saltier and the score increased from 1.10 on day 1 to 1.43 on day 45. The white cheese became saltier during the ripening period due to the concentration of salt in cheese [10, 39]. ElOwni and Hamid [25] reported that the maximum saltiness score of white cheese was reached on day 180 then the cheese became less salty as the ripening progressed.

The cheese was more acceptable on day 15 (3.15) and as the ripening period progressed its acceptability deteriorated until it became least acceptable at the end of the ripening period (2.94).These results agree with Elmahi and ElZubeir [39] who found that the maximum acceptability of white cheese was reached on day 10 then cheese started to deteriorate toward the end of the ripening period, and Salih and Abdalla [10] who reported that overall acceptability score of pasteurized milk cheese produced with starter culture reached the highest score on day 15 then the score decreased toward the end of the ripening period. Abdalla et al. [41] reported that white cheese became less acceptable toward the end of the ripening period of 180 days. These results may be due to the proteolytic and lipolytic activities of microorganisms [10].

4. Conclusion

The addition of the starter culture is an essential step toward improving cheese making. This is evident from the results obtained in this study, where there was an improvement in the quality of the cheese from a microbiological perspective and there was also a slight improvement in the physicochemical and sensory properties of the cheese that was manufactured using the starter culture. An improvement in the microbiological quality of the cheese was also observed during the repining period. Therefore, legislation must be adopted to use the starter culture in the manufacture of artisanal Sudanese white cheese to obtain a safe product.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare no competing interest.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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