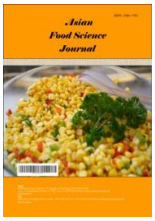

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Effect of Starter Addition on the Physicochemical, Microbiological and Sensory Characteristics of Pasteurized Milk White Cheese (*Gibna bayda*)

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Authors' contributions

This work was carried out in collaboration between both authors. Author HS designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MOMA performed the statistical analysis, managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: This study was conducted to determine the effect of starter culture addition on the physicochemical, microbiological and sensory characteristics of white cheese (*Gibna Bayda*) during the storage period (5°C/ 45 days).
Methodology: Two treatments were prepared: Treatment 1 (T1): cheese manufactured with pasteurized milk with *Lactobacillus bulgaricus* and *Streptococcus thermophilus* (1:1) at the level of 2% (w/v); Treatment 2 (T2): the control; cheese manufactured with pasteurized milk without starter cultures. After cheese manufacture, physicochemical, microbiological and sensory characteristics were determined at 1, 15, 30 and 45-day intervals.
Results: Results showed that the starter culture addition did not significantly (P>.05) affect all physiochemical characteristics of cheese, except for the ash content which was high in cheese manufactured with the addition of starter culture. The addition of the starter influenced the microbiological quality of the cheese, with total viable bacteria, *Staphylococcus aureus* and yeasts

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and moulds counts being significantly (P<.05) low. Furthermore, the cheese made with an added starter culture showed high scores of colour, taste and flavour. The storage period significantly affected all characteristics of the cheese, except for the fat content of the control, which remained unchanged during all storage periods.

Conclusion: The results of this study show that starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) (1:1) is likely to be a suitable culture for Sudanese white cheese.

Keywords: Gibna bayda; microbiological; white cheese; storage period; lactic acid bacteria.

1. INTRODUCTION

Milk is highly perishable food. Thus, its processing into cheese or other fermented dairy products provides an ideal vehicle for the preservation of its nutrients (vitamins, minerals, protein, etc.), making them available throughout the year [1]. About one third of the world's milk production is used in the manufacture of cheese, which is a highly nutritious food that offers a diversity of flavors [2].

Cheese-making is the major preservation method in Sudan, especially during the rainy season when plenty of milk is available [3]. White cheese is the main type of cheese in Sudan, in addition to other cheese varieties such as *mudaffara* (braided) and mozzarella cheeses [4], which vary in composition, texture, color, taste, and flavor. The variation is due to the composition of milk, production methods, microbial flora, type of package, microbial activity during ripening and ripening conditions. Sudanese white cheese is in the category of soft and semi-soft cheeses of the East Mediterranean area and North Africa [5]. It is unique among cheese varieties in which a high concentration of table salt (sodium chloride) is added to the milk before processing [6]. The cheese is usually left overnight to drain the whey with or without pressing, and the ripening happens while the cheese is submerged in the whey [7].

In Sudan, cheeses are produced throughout the country, especially in El Dueim, White Nile, El Obeid, North Kordofan, Nyala, South Darfur, Darfur provinces [8]. In these different geographical locations white soft cheese is made by experienced cheese makers following the traditional methods. Nowadays, El Dueim town is considered as the most important center for the manufacturing of white cheese (Jibna-beida), and this town alone supplies about 60% of the total cheese for the Sudanese market [8]. The cheese is usually manufactured from raw milk [5] with no starter culture addition and only the natural lactic acid bacteria present in the raw milk carry the fermentation process needed for cheese maturation [9]. Using raw milk leads to unpredictable chemical changes or possible survival of various pathogens during manufacture and ripening [10,11]. A high bacterial load was found in Sudanese white cheese samples collected from different producers in rural areas of New Halfa, eastern Sudan [12]. Another study conducted by Nour Eldaim and El Zubeir [13] showed that there is a high incidence of coliform bacteria in Sudanese white cheese. The presence of *S. aureus* in cheese made with the use of non-pasteurized milk was reported by El-Hag [14]. Pasteurization of milk for cheese making may be thought to be extremely important for the control of pathogenic organisms and allow the making of a uniform product of constant quality [15]. Moreover, fresh cheese made from heat-treated milk was superior to that made from raw milk regarding the body and texture [16].

Recently, pasteurized milk was used instead of raw milk in systematized cheese dairies, making necessary the use of lactic acid bacteria (LAB), a group of Gram-positive, non-spore forming, cocci or rods, which produce lactic acid as the major end product during the fermentation of carbohydrates. Lactic acid bacteria and their products give the fermented foods the distinctive flavours, textures and aromas. In addition, they can produce antimicrobial substances including bacteriocins that have ability to inhibit pathogenic and food spoilage bacteria [17,18]. The main role of lactic acid bacteria used as starter during cheese production is the production of lactic acid through metabolism of lactose. This action improves the milk coagulation process, makes the curd stronger [19,20].

The possibility of improving the properties of Sudanese white cheese, especially through modifications of the manufacturing processes (e.g. by the introduction of pasteurization and the use of starter cultures) is an interesting approach to be researched. Thus, this study was conducted to evaluate the physicochemical,

microbiological and sensory characteristics of white cheese as affected by a starter culture addition.

2. MATERIALS AND METHODS

2.1 Materials

Raw cow's milk was supplied from Sudan University of Science & Technology Farm in Faculty of veterinary medicine & animal production (Khartoum, Sudan). Rennet powder and Direct Vat Set (DVS) starter culture (*Lactobacillus bulgaricus* and *Streptococcus thermophilus* 1:1) were obtained from Chris Hansen's Laboratory (Denmark). The salt was purchased from a local market.

2.2 Cheese Manufacture

Cheese was manufacture according to the method described by Ibrahim [21] with some modifications. Fourteen liters (14 liters) of fresh clean cow's full cream milk was pasteurized at 72°C for 1 minute, then sodium chloride (2% w/w) was added, followed by cooling milk to 45°C and addition of $CaCl_2$ (0.02% w/w). The milk samples were then transferred into two stainless steel containers (7 L in each one) for cheese manufacture and then cooled to 42°C. DSV commercial starter (*Streptococcus thermophillus and Lactobacillus bulgaricus*) in the ratio of 1:1% concentrate was added at the level of 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 undisturbed for 30 min to develop acidity, then rennet powder (1.3 g 50 L^{-1} milk) was dissolved in 50 ml of distilled water and added to both treatments at 40°C. Milk was then stirred manually for 20 minutes and then left undisturbed to develop curd. The curd was cut into small cubes (2.5x2.5x2 cm) by a sterile stainless-steel knife and then, allowed to rest in the whey for 10-15 min. The curd was poured into small clean wooden molds lined with cheese cloth and pressed by 1 kg weight overnight. The next day, brine solution was prepared by adding salt to the collected whey (2% w/v), and pasteurized at 72°C for 1 minutes and cooled to 40°C. The pressed cheese was cut into small cubes ($2.5 \times 2.5 \times 2.5$ cm) and then transferred to the prepared brine solution for 24 h. The brined cheeses blocks were then packed into plastic containers 100 g in each, and stored in the refrigerator at 5°C for 45 days (Fig. 1). The manufacture of cheese was performed in triplicate. The microbiological, physicochemical and sensory characteristics of cheeses were determined at 1, 15, 30 and 45-day intervals in duplicate.

2.3 Physicochemical Analysis of Cheese Milk

Sample from whole raw milk was collected after thorough mixing, in clean bottles (200 mL), and transported quickly to the laboratory for the chemical analysis. The total solids content, fat content, protein content and titratable acidity were determined according to standard methods of the Association of Official Analytical Chemists [22].

2.4 Physicochemical Analysis of Cheese

The fat content was determined according to International Organization for Standardization (ISO) method [23]. While the total solids content, ash content, protein content and titratable acidity were determined according to standard methods of the Association of Official Analytical Chemists [24-27].

2.5 Microbiological Examination of Cheese

2.5.1 Preparation of samples

The sample (11 g) was weighed aseptically in a sterile blender jar, and 99 mL of sterile peptone water was added and manually blended for 2 min to make a 10^{-1} dilution. A tenfold dilution was made up to 10^{-8} using sterile peptone water. After inoculation at the required temperature, the results were calculated as colony-forming units per gram of sample (cfu g^{-1}) [28,29].

2.5.2 Total viable bacterial count (TVBC)

Plate count agar (Himedia, M091) was used for the count of TVB [30]. Sample decimal dilution (1 mL) was transferred into Petri dishes in duplicate followed by the addition of 18-20 mL melted and cooled medium (45°C). Petri dishes then, mixed thoroughly by rotating the dishes firstly in one direction and then in opposite direction. The inoculated plates were incubated at 37°C for 48 h. Colonies of each plate were counted using a manual colony counter (Scan 100) and the total viable bacterial count was calculated as CFU g^{-1}.

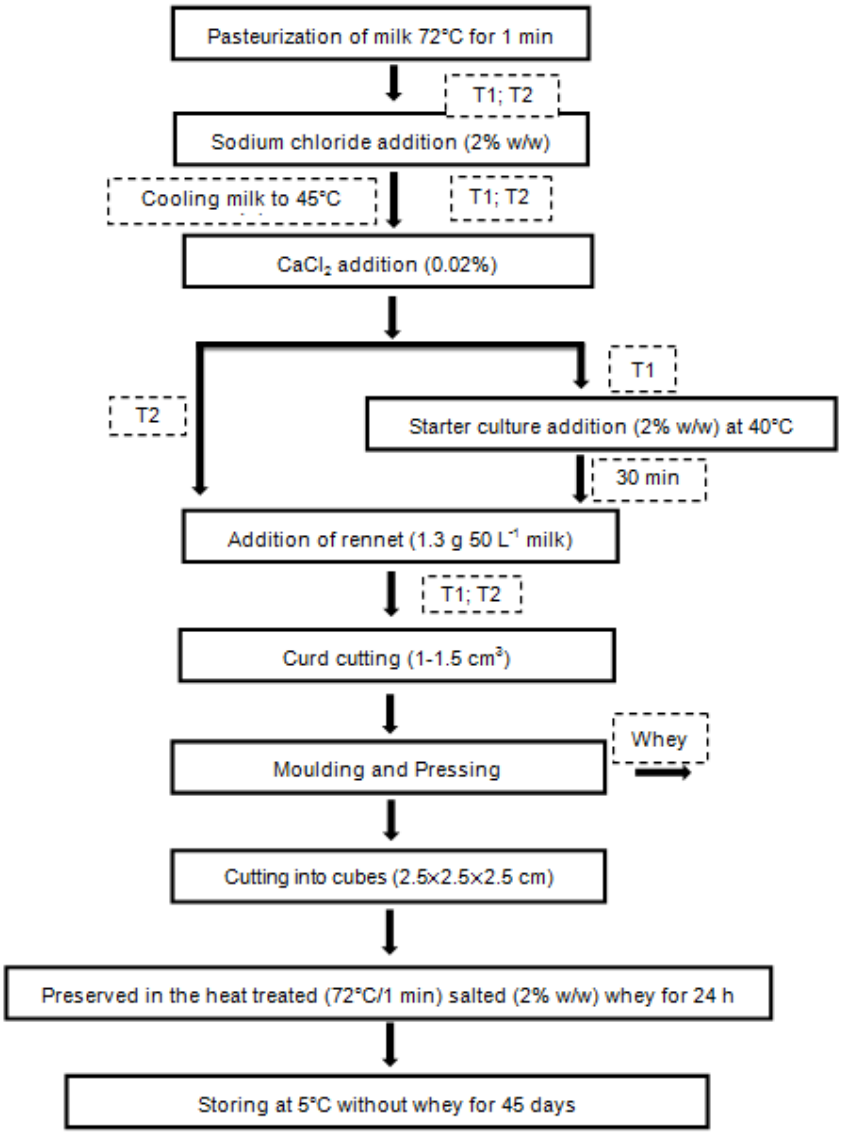

Fig. 1. White cheese manufacturing process

T1 = Cheese made with starter culture; T2 = Cheese made without starter culture

2.5.3 *Staphylococcus aureus* count

Mannitol salt agar (Micro master, DM160) was used for the count of coagulase-positive staphylococci [30]. Sample decimal dilutions (0.1 mL) was transferred into a pre-solidified medium and spread plated using a sterile glass rod. The plates were incubated in an inverted position at 37°C for 48 h [31]. Bright yellow colonies were recognized as *Staphylococcus aureus*. Colonies were counted with manual colony counter (Scan 100) and regarded as colony-forming units per gram sample (CFU g^{-1}).

2.5.4 *Escherichia coli* count

Brilliant green lactose bile (BGB) broth (Merck, 736) and peptone water (Himedia, M028) were used for the count of *E. coli* using the most probable number technique. Positive MacConkey broth tubes in total coliform counts were gently agitated and one loopful from each tube was transferred to a tube of BGB broth and another loopful to a tube of peptone water (tryptone water). Both tubes were incubated at 44.5°C for 24-48 h, after which 0.2 mL of Kovac's reagent was added, shaken and left to stand for 10 min

for indole production. Tubes of BGB broth were examined for turbidity and gas formation in Durham tubes. Positive results indicated the presence of *E. coli* and were used for further confirmation by streaking a loopful from each tube on Eosin methylene blue (EMB) agar (Millipore, 70186) for the identification of colonies that show nucleated dark center with or without metallic sheen, which are characteristic features of the growth of *E. coli* in the medium. The isolates were further characterized by conventional biochemical tests according to Barrow and Feltham [32]. Special attention was paid to the pattern of reactions of the organism in IMViC (indol, methyl red, **V**oges-Proskauer, and citrate) tests. *E. coli* most probable number per mL of sample was calculated from the number of positive tubes of BGB broth and peptone water [33,34].

2.5.5 Yeasts and moulds count

Yeast extract agar (Himedia, M456) was used for the count of yeasts and moulds. Sample decimal dilutions (0.1 mL) were transferred into a pre-solidified medium and spread plated using a sterile glass rod [35]. The plates were incubated at 25°C for 5 days. Yeasts and moulds colonies were counted by manual colony counter (Scan 100) and recorded as CFU g^{-1} [29].

2.6 Sensory Evaluation of Cheese

Samples were left at room temperature two hours before sensory testing. All samples were presented in plastic trays. A panel consisted of ten trained panelists familiar with the product were chosen and asked to judge on the quality of the cheese (color, flavor, body, taste, saltiness and overall acceptability) using an evaluation sheet, where color ranged from 1= not acceptable to 4 = acceptable; flavor 1 = bland to 4 = extremely intense; taste 1 = absent to 4 = excessive acid; body 1 = smooth to 4 = pasty; saltiness 1 moderate to 4 = too salty; overall acceptability 1 = unacceptable to 4 = acceptable [36].

2.7 Statistical Analysis

Statistical analyses were performed using the Statistical Analysis Systems (SAS, ver. 9). A factorial design (2×4) was used to determine the effect of starter culture on the physicochemical, microbiological, and sensory characteristics of white cheese (*Gibna bayda*) during the storage period. Duncan's multiple ranges tests were carried out for mean separation between treatments (P<.05). All analyses were performed in triplicate. All data were presented as means.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Characteristics of Cheese Milk

The physicochemical characteristics of cheese milk were 5.2%, 3.62%, 13%, 0.7% and 0.2% for fat, protein, total solids, ash contents, and acidity, respectively. The results of the protein content, fat content, and acidity are in line with Elsheikh [37] who found that the chemical composition of milk from Khartoum North contained fat of 4.72%, total protein of 3.57% and acidity of 0.23. The results of the total solids and ash content agree with that reported by Abd Elrahman [38] for raw milk.

3.2 Effect of the Starter Culture Addition on the Physicochemical Characteristics of White Soft Cheese

The physicochemical characteristics of white cheese are presented in Table 1. All physicochemical characteristics were not significantly (P>.05) affected by the addition of starter culture, except ash content which was significantly (P=.05) higher in the cheese made with the addition of starter culture (6.33%). This result is in line with that of Evangelia [39] who found that he addition of probiotic lactobacilli in cheese indicated no significant change in the composition. The result of fat content is in agreement with that of Yerlikaya and Ozer [40] who found that the fat properties of cheese were not influenced by added probiotic bacteria. Although the protein content was not significantly (P>.05) affected by the addition of starter culture, the higher content (18.51%) was in cheese made with starter culture added, and this is in accordance to Hussein and Shalaby [41] who found cheese made with yoghurt starter to show an increase in total protein content and Najafi [19] who reported that the protein content of cheese increased with the starter culture addition. This result could be attributed to the lower pH at renneting that resulted in reduced net charge on casein micelles and improved the activity of rennet leading to greater protein recovery in the curd [42,43,44]. Although the total solids content was not significantly (P>.05) affected by the starter culture addition, the higher content (47.49%) was found for the cheese made with an added starter culture. This result is consistent with that of Sert [45] who reported that

the use of the culture caused the higher titratable acidity in cheese increasing the extent of whey separation and resulting in increased total solids. Moisture content was not significantly (*P*>.05) affected by the starter culture addition. The result reported by Ekici [46] is similar, as they observed that starter culture did not significantly affect moisture content.

The physicochemical characteristics of white cheese as affected by the starter culture addition and storage period are presented in Table 2. All Physicochemical characteristics were significantly affected by the storage period, except the fat content of cheese made without starter culture addition remained constant during all storage periods. However fat content of cheeses made with starter culture increased to a maximum of 27.13% on day 30 before decreasing again towards the end (24.69%). The protein content of cheeses made with and without starter culture decreased during storage period to 17.15% and 15.73%, respectively at the end of storage. The total solids content of cheeses made with and without starter culture increased to maximum (50.86% and 52.23%, respectively) at day 15 before decreasing again towards the end (46.56% and 47.48%, respectively). The moisture content of both kinds of cheese followed the same trend decreasing to the lowest value at day 15 (49.14% and 47.78% for cheese made with and without starter culture, respectively), then steadily increased towards the end of storage period (55.44% and 52.53%, respectively). This may be due to the fastest drop in pH during the first 15 days of ripening. Ash content of cheese made with starter culture decreased to 5.54% on day 30 before increasing again, while that of cheese made without starter culture reached the minimum value (4.33%) on day 15, then slightly increased. The acidity of cheese made with and without starter regularly increased from 0.28% and 0.27%, at day 1 to 0.74% and 0.85%, respectively at the end.

Table 1. Effect of starter culture addition on the physicochemical characteristics of white cheese (*Gibna bayda*) made from pasteurized milk

Physiochemical characteristics (%)	Without starter	With starter	SE	SL	P
Fat	24.11^{a}	24.30^{a}	0.542	NS	0.8075
Protein	17.81^{a}	18.51^{a}	0.872	NS	0.5742
Total solids	47.23^{a}	47.49^{a}	0.847	NS	0.8232
Moisture	52.78^{a}	53.44^{a}	0.825	NS	0.5722
Ash	5.52^{a}	6.33^{b}	0.191	*	0.0136
Acidity	0.58^{a}	0.56^{a}	0.064	NS	0.8165

*Means in the same row bearing similar superscripts are not significantly different (P>.05) according to Duncan's test. * = P<.05, NS = Not significant, SL = Significance level, SE = Standard error of means*

Table 2. Effect of storage period on the physiochemical characteristics of white cheese (*Gibna bayda*) made from pasteurized milk

Physiochemical characteristics (%)	Storage period (days)				SE	SL	*P*
	1	15	30	45			
Without starter							
Fat	23.00^{a}	24.88^{a}	23.94^{a}	24.63^{a}	0.742	NS	0.2901
Protein	19.65^{a}	19.31^{ab}	16.55^{ab}	15.73^{b}	1.219	*	0.0408
Total solids	41.68^{c}	52.23^{a}	47.53^{b}	47.48^{b}	1.173	***	<0.0001
Moisture	58.33^{a}	47.78^{c}	52.48^{b}	52.53^{b}	1.173	***	<0.0001
Ash	6.55^{a}	4.33^{c}	5.83^{ab}	5.36^{b}	0.299	***	<0.0001
Acidity	0.27^{c}	0.51^{bc}	0.68^{ab}	0.85^{a}	0.087	***	<0.0001
With starter							
Fat	19.38^{c}	26.00^{ab}	27.13^{a}	24.69^{b}	0.738	***	<0.0001
Protein	22.50^{a}	17.08^{b}	17.30^{b}	17.15^{b}	1.162	**	0.0027
Total solids	43.75^{c}	50.86^{a}	48.80^{ab}	46.56^{bc}	1.140	***	0.0003
Moisture	57.85^{a}	49.14^{b}	51.33^{b}	55.44^{a}	1.078	***	<0.0001
Ash	8.05^{a}	5.65^{b}	5.54^{b}	6.06^{b}	0.315	***	<0.0001
Acidity	0.28^{b}	0.50^{ab}	0.71^{a}	0.74^{a}	0.089	**	0.0018

*Means in the same row bearing similar superscripts are not significantly different (P>.05) according to Duncan's test *** = P<.001, ** = P<.01, *= P<.05, NS = Not significant, SL = Significance level, SE = Standard error of means*

3.3 Effect of the Starter Culture Addition on the Microbiological Quality (log_{10} cfu g^{-1}) of White Soft Cheese

Microbiological quality (log_{10} cfu g^{-1}) of white cheese as affected by starter culture addition is presented in Table 3. Total viable bacteria, *S. aureus*, and yeasts and moulds counts were significantly affected by starter culture addition, while *E. coli* count was not (*P*>.05). The total viable bacterial count was significantly *(P*=.05) lower in cheese made with the addition of starter culture (log_{10} 6.61 cfu g^{-1}). *S. aureus* was significantly (*P*<.01) affected by starter culture, with the lower count (log_{10} 0.76 cfu g^{-1}) for the cheese made with an added starter culture. This result is in agreement with that of Arqués [47] who found that the *S. aureus* count in cheese made with the addition of starter culture was lower than in cheese made without a starter culture. *E. coli* count was not significantly (*P*<.01) affected by the starter culture, although the lower count (log_{10} 0.51 cfu g^{-1}) was obtained from cheese made with a starter culture. The addition of starter culture resulted in a reduction in the number of *S. aureus* and *E.* coli, and these results are in agreement with those of Tesfaye [48] who reported that mixed lactic cultures had a remarkable effect on reducing the foodborne pathogens during souring milk. The reduction in the number of *S. aureus* and *E. coli* may be attributed to the effective inhibitive activity of starter cultures against pathogenic and spoilage microorganisms, which includes the production of organic acids and subsequent pH decrease and act as strong competitors for nutritional factors like nicotinamide, biotin or niacin [49,50]. The moulds and yeasts count was significantly (*P*<.001) affected by the starter culture addition, the lower count (log_{10} 4.85 cfu g^{-1}) was observed for the cheese made with a starter culture, and these results are in line with those of Fernandez [17] who reported that lactic acid bacteria had a remarkable effect on reducing yeast and mold in soft cheese, and this may be due to bactericidal and bacteriostatic effect of lactic acid bacteria [51]. *Staphylococcus aureus and E. coli* bacteria were not found within the range of microbial limits (0) according to Sudanese Standards and Metrology Organization (SSMO) [52]. The presence of *Staphylococcus aureus* and *E. coli* in the cheese might be due to the poor sanitary conditions and contamination of cheese during processing and storage [53]. Centre for Food Safety (SFC) [54] reported that the number of entrances of ripened cheeses can be accepted in the range of 10^2-10^4 cfu/g^{-1}.

Microbiological quality (log_{10} cfu g^{-1}) of white cheese as affected by starter culture addition and storage period is presented in Table 4. Total viable bacteria, *S. aureus*, *E. coli* and yeasts, and moulds counts were significantly affected by the storage period. The total viable bacteria count significantly (*P*<.001) decreased from log_{10} 6.56 and log_{10} 7.17 cfu g^{-1}, respectively, at day one to log_{10} 6.43 and log_{10} 6.62 cfu g^{-1}, respectively, on day 30. Then, they increased at the end of storage. These results are in disagreement with those of Abdel Razig and Babiker [55] who found that total viable bacteria count decreased during storage period due to the effect of acid and heat which suppresses the increase at the end of storage. The increasing trend is in agreement with the results of Abdalla and Mohammed [56] who found that a slight increase in total viable bacteria count was noticed at the end of the storage period. This increase can be explained by sufficient change in the environmental conditions during the ripening which allowed the growth and multiplication of microorganisms [3]. *S. aureus* showed a high count during the early period of ripening (day 1) in cheese made with and without starter culture addition (1.18 and 2.92, respectively) and then decreased during the ripening period. *S. aureus* can multiply rapidly, especially during the initial phase of preparation when natural lactic acid bacteria are in lag phase and a sufficient amount of lactic acid has not been produced, and then significantly reduced in acidic conditions [57]. *E. coli* was not detected in all cheeses at day 1. In cheese made with starter culture addition *E. coli* count increased up to day 15 (log_{10} 1.20 cfu g^{-1}) then dropped (log_{10} 0 cfu g^{-1}) at day 30, before increasing again at the end (log_{10} 0.83 cfu g^{-1}). These results are in line with Manolopoulou [58] who showed an initial increase in the number of *E. coli* in cheese in the first 10 days followed by a decrease. This result could be due to the decline in pH of cheese throughout the storage period [59]. Yeasts and moulds count showed a continuous increase with progress in the storage period. These findings are in agreement with Aly and Galal; El Owni and Hamid [60,3] and Abdalla and Mohammed [56] who reported that yeasts and moulds increased as the storage period progressed. The constant increase of moulds and yeasts during storage might be because yeasts and moulds could metabolize lactic acid and the lower pH [61].

Table 3. Effect of starter addition culture on the microbiological characteristics (log10 cfu g^{-1}) of white cheese (*Gibna bayda*) made from pasteurized milk

Microbiological characteristics	Without starter	With starter	SE	SL	P
TVB	6.82^{a}	6.61^{b}	0.053	**	0.0083
S. aureus	1.60^{a}	0.76^{b}	0.206	**	0.0053
E. coli	0.76^{a}	0.51^{a}	0.299	NS	0.5538
Yeasts and moulds	5.77^{a}	4.85^{b}	0.176	***	0.0005

*Means in the same row bearing similar superscripts are not significantly different (P>.05) according to Duncan's test *** = P<.001, ** = P<.01, NS = Not significant, SL = Significance level, SE = Standard error of means*

Table 4. Effect of storage period on the microbiological characteristics (log10 cfu g^{-1}) of white cheese (*Gibna bayda*) made from pasteurized milk

Microbiological characteristics	Storage period (days)				SE	SL	*P*
	1	15	30	45			
Without starter addition							
TVB	7.17^{a}	6.63^{c}	6.62^{c}	6.88^{b}	0.048	***	<0.0001
S. aureus	2.92^{a}	1.73^{b}	1.15^{bc}	0.62^{c}	0.302	***	<0.0001
E. coli	ND	1.59^{a}	1.45^{a}	ND	0.479	*	0.0251
Yeasts and moulds	5.36^{b}	5.72^{ab}	5.77^{ab}	6.22^{a}	0.176	*	0.0119
With starter addition							
TVB	6.56^{bc}	6.72^{ab}	6.43^{c}	6.88^{a}	0.093	***	0.0005
S. aureus	1.18^{a}	0.60^{ab}	1.95^{ab}	0.31^{b}	0.258	*	0.0115
E. coli	ND	1.20^{a}	ND	0.83^{ab}	0.325	*	0.0222
Yeasts and moulds	4.11^{b}	4.80^{ab}	5.38^{a}	5.13^{a}	0.289	*	0.0189

*Means in the same row bearing similar superscripts are not significantly different (P>.05) according to Duncan's test. *** = P<.001, * = P<.05, SL = Significance level, SE = Standard error of means, ND = Not detected*

3.4 Effect of the Starter Culture Addition on the Sensory Characteristics of White Soft Cheese

Sensory characteristics of white cheese as affected by starter culture addition are presented in Table 5. Colour, taste, body, and saltiness were significantly affected by starter culture addition, while flavor and overall acceptability were not. The taste was significantly (*P*<.05) higher (2.30) in cheese made with starter culture addition. This result is in agreement with Ahmed [62] who found that the use of EPS-producing lactic starter cultures improved the sensory attributes of Karish cheese. Colour was significantly (*P*<.01) higher (3.44) in cheese made with starter culture addition. This result is in line with Olarte [63] who found that cheeses made with starter culture received the most favorable scores from the tasting panel for colour. Flavour was not significantly (*P*>.05) affected by the starter culture. These results are in agreement with Sabbagh [64] who found that the addition of adjunct culture had no significant effect on flavor. The body was significantly (*P*<.01) higher (2.45) in cheese made without starter culture addition. This result is in disagreement with that of Sulejmani [65] and Kourkoutas [66] who found that Feta-type cheese produced with freeze-dried culture revealed a better texture and structure. This was probably due to the rapid initial acid production by the starter cultures [63]. The saltiness was significantly (*P*<.05) higher (2.45) in cheese made without starter culture addition. The overall acceptability was not significantly (*P*>.05) affected by starter culture addition. This result is in agreement with that of Hayaloglu [67]. Although the cheese made with and without starter culture received similar overall acceptability score the grader's differentiated the 2 cheese awarded the cheese made with the starter cultures the best score of flavor and odor.

The sensory characteristics of white cheese as affected by starter culture addition and storage period are presented in Table 6. All sensory characteristics were significantly affected by the storage period. The colour score of the cheese made with starter culture remained constant till day 30, and then significantly (*P*<.05) decreased to 3.05 on day 45. While the colour score of the cheese made without starter culture remained constant (3.30) till day 15, and then significantly (*P*<.01) decreased to 3.15 on day 45. Flavor score was significantly (*P*<.001) increased during

the storage period till day 45 (3.20 and 2.70, respectively) for cheese made with and without starter culture addition. These findings are in agreement with those of Abdalla and Mohamed [36] who reported that flavor of cheese gradually improved as storage period progressed, and the improvement in flavor might be due to the natural flora initially present in milk which participated in flavor production [68]. The taste score was significantly (*P*<.01) increased during the storage period till day 45 (2.45 and 2.25, respectively) for cheese made with and without starter culture addition. This increase might be due to a complex series of biochemical, and probably some chemical events caused by agents from several sources like residual coagulant (usually chymosin), starter, and adventitious non-starter microflora [69]. The body scores significantly (*P*<.001) increased during the storage period in cheese made with starter culture addition. This result is in agreement with the result of Hattem [70] who found that the body improved with the increase in the ripening time. The improvement in cheese structure is due to the production of lactic acid [71]. Saltiness of the cheese made with and without starter culture addition significantly (*P*<.001) increased during the storage period to scored highest (1.65) at day 15 and (1.90) at day 30, respectively, and then gradually decreased towards the end. These findings are in line with Abdalla and Mohammed [56]. Overall acceptability score was significantly (*P*<.001) increased from 2.65 on day 1 to 2.95 on day 15 then decreased towards the end (2.15) for cheese made with starter culture addition. These results are consistent with those of Hamad [72] who found that Karish cheese had the best organoleptic properties after 15 days of storage, but had lower scores when they were after 30 days. The decreasing trend might be due to the lipolytic and proteolytic actions of microorganisms [73].

Table 5. Effect of starter culture addition on the sensory characteristics of white cheese (*Gibna bayda*) made from pasteurized milk

Sensory characteristics	Without starter	With starter	SE	SL	P
Colour	3.19^{b}	3.44^{a}	0.062	**	0.0039
Flavor	2.65^{a}	2.79^{a}	0.067	NS	0.1458
Taste	2.10^{b}	2.30^{a}	0.062	*	0.0231
Body	2.45^{a}	2.18^{b}	0.064	**	0.0027
Saltiness	1.64^{a}	1.45^{b}	0.051	*	0.0101
Overall acceptability	2.56^{a}	2.48^{a}	0.084	NS	0.4612

*Means in the same row bearing similar superscripts are not significantly different (P>.05) according to Duncan's test. ** = P<.01, * = P<.05, NS = Not significant, SL = Significance level, SE = Standard error of means*

Table 6. Effect of storage period on the sensory characteristics of white cheese (*Gibna bayda*) made from pasteurized milk

Sensory characteristics	Storage period (days)				SE	SL	*P*
	1	15	30	45			
Without starter addition							
Colour	3.30^{a}	3.30^{a}	3.00^{b}	3.15^{b}	0.086	***	<0.0001
Flavor	2.30^{b}	2.90^{a}	2.70^{a}	2.70^{a}	0.130	***	<0.0001
Taste	1.80^{c}	2.25^{ab}	2.10^{b}	2.25^{a}	0.145	**	0.0054
Body	1.90^{c}	2.45^{b}	2.75^{ab}	2.70^{a}	0.146	***	<0.0001
Saltiness	1.40^{c}	1.55^{a}	1.90^{b}	1.20^{ab}	0.094	**	0.0096
Overall acceptability	2.20^{b}	2.50^{a}	2.85^{ab}	2.65^{b}	0.155	***	0.0004
With starter addition							
Colour	3.55^{a}	3.70^{a}	3.45^{a}	3.05^{b}	0.859	*	<0.0001
Flavor	2.55^{b}	2.20^{b}	3.20^{a}	3.20^{a}	0.130	***	<0.0001
Taste	1.85^{b}	2.40^{a}	2.50^{a}	2.45^{a}	0.145	**	0.0054
Body	1.70^{b}	2.00^{b}	2.55^{a}	2.45^{a}	0.146	***	<0.0001
Saltiness	1.20^{b}	1.65^{a}	1.50^{a}	1.45^{ab}	0.942	**	0.0098
Overall acceptability	2.65^{a}	2.95^{a}	2.15^{b}	2.15^{b}	0.155	***	0.0004

*Means in the same row bearing similar superscripts are not significantly different (P>.05) according to Duncan's test. *** = P<.001, ** = P<.01, * = P<.05, SL = Significance level, SE = Standard error of means*

4. CONCLUSION

Considering physicochemical, microbiological and sensory evaluation results, it could be concluded that Sudanese white cheese (*Gibna Bayda*) can be produced with high quality and acceptability using of 2% Direct Vat Set (DVS) starter culture (*Lactobacillus bulgaricus and Streptococcus thermophilus* 1:1). The use of this starter culture would be desirable in order to improve the microbiological quality and acceptability of Sudanese white cheese without significantly changing its typical properties.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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