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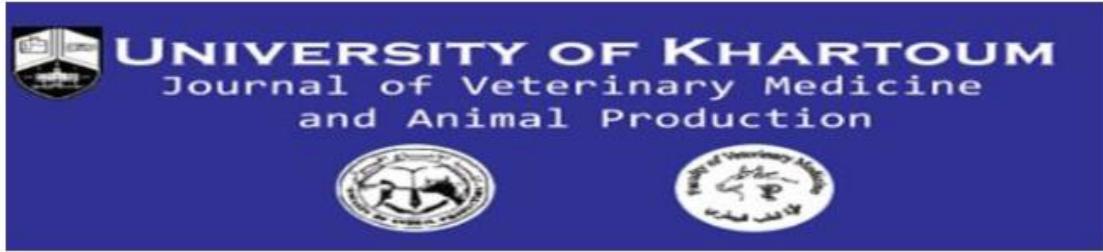
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Evaluation of the Effect of Starter Culture on the Quality of White Soft Cheese (Gibna Beyda)

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Abstract

This investigation was carried out to study the effect of starter culture on the quality of white soft cheese (*Gibna Beida*), yield and coagulation time. White soft cheese was made from fresh cows milk (heated at 65°C for 30 minutes, then cooled to 35°C), then starter culture was added at different concentrations (1.5, 2.0, 2.5%) in addition to CaCl₂ (0.02%), NaCl (2%) and rennet. Chemical analysis, microbial analysis and sensory evaluation were carried out. The coagulation time for cheese made without addition of starter culture (control) was 189 min. and the yield was 9.61%. The obtained results indicated that the use of starter culture at concentration of 2.5% showed reduction in coagulation time to 64 min. and increase in yield to 13.51%. The effect of different concentrations of starter culture on the chemical composition of white soft cheese revealed that the moisture content showed a significant increase from 56.15% to 69.17%, acidity increased from 0.22% to 0.32%, fat content decreased from 27.60% to 21.00%, protein content decreased from 15.00% to 9.40%, total solids decreased from 43.77% to 31.80%. The total bacterial count increased from 2.3 10⁴ to 4.1 10⁶, the yeast count increased from 8.5 10⁴ to 1.7 10⁵. The flavor and overall acceptability were affected by the addition of starter culture. The best flavor and best overall acceptability scores were obtained in cheese made with 1.5% starter culture, while the least score to flavor was obtained in cheese made with 2.5% starter culture.

المستخلص

أجريت هذه الدراسة لتقييم أثر إضافة البادئ بنسب تركيز مختلفة على جودة الجبنة البيضاء، الكمية المنتجة منها و الزمن اللازم لتخثرها. تم إنتاج الجبنة البيضاء باستخدام لبن الأبقار الطازج حيث يتم تسخينه على درجة حرارة 65 م لمدة 30 دقيقة ثم تبريده لدرجة حرارة 35 م ثم إضافة البادئ بنسب تركيز مختلفة (1.5، 2.0، 2.5 %) يضاف أيضا كلوريد الكالسيوم (0.02 %) و كلوريد الصوديوم (2.0 %) و حبوب الريني. بعد الانتهاء من تصنيع الجبنة البيضاء تم إجراء التحاليل الكيميائية و الميكروبيولوجية و التقييم الحسي. بلغ الزمن اللازم للتخثر 189 دقيقة و نسبة الإنتاج 9.61 % في عينة الجبنة التي لم يتم فيها إضافة للبادئ بينما انخفض الزمن اللازم للتخثر إلى 64 دقيقة و ارتفعت نسبة الإنتاج إلى 13.51 % في العينة التي تم فيها إضافة البادئ بنسبة 2.5 %. تلخص تأثير النسب المختلفة من البادئ على التركيب الكيميائي للجبنة البيضاء في الآتي: ارتفعت نسبة الرطوبة من 56.15 إلى 69.17 %، ارتفعت نسبة الحموضة من 0.22 إلى 0.32 %، انخفضت نسبة الدهون من 27.60 إلى 21.00 %، انخفضت نسبة البروتين من 15.00 إلى 9.40 %، انخفضت نسبة المواد الصلبة من 43.77 إلى 31.80 % بينما زاد العدد الكلي للبكتيريا من 2.3 * 10⁴ إلى 4.1 * 10⁶ و ارتفع عدد الخمائر من 8.5 * 10⁴ إلى 1.7 * 10⁵. كان لإضافة البادئ تأثير على الصفات الحسية وبالأخص النكهة و القبول الكلي للعينة. لقد نتج عن إضافة البادئ بنسبة 1.5 % الحصول على أفضل نكهة و أكبر نسبة للقبول الكلي للجبنة البيضاء، بينما انخفضت نسب النكهة و القبول الكلي انخفاضاً ملحوظاً للعينة التي أضيف لها البادئ بنسبة 2.5 %.

Introduction

Milk is a complex biological fluid, secreted by the mammary glands in lactating mammals. The major constituents of milk include water, lactose, fats, protein, minerals, vitamins and enzymes. The unique composition and properties of milk make it an ideal food for the mammalian neonate (Tannahil, 2008). When the supply of fresh milk is in surplus, the producers try to make the best use of it to avoid falling down of milk prices. So milk can be separated into cream or processed into cheese, butter or yoghurt. Approximately one third of the world milk production is used in cheese manufacture (Tannahil, 2008). The manufacture of cheese is a form of milk preservation as milk is highly perishable (El Owni and Hamid, 2007). Cheese is highly nutritious food, with many diverse flavours and textures (Winstein, 2017 and Suliman *et al.*, 2013).

Cheese can be used as a snack or as a part of dish or prepackaged convenience food, supplies abundant quantities of proteins, fat and calcium, which are essential for good health and growth (Quinee, 2004). The individual characteristics of each type of cheese are due to the type of milk, the microbial starter culture and the manufacturing procedure used (El Khider *et al.*, 2012).

Traditionally, the white cheese is processed in the Sudan by natural fermentation induced by microorganisms either present in the raw milk or from the surrounding environments. Starter cultures are not usually used in the processing of Sudanese white cheese. (Ahmed, 1997). Various starter culture types are used in the dairy industry for cheese making. The lactic acid bacteria are used to induce lactic fermentation which is very essential in the manufacture of cheese and fermented milk products (Kats and Pollan, 2012). The use of starter culture in the production of cheeses encourages whey separation, inhibits the growth of pathogenic bacteria, generates some aroma compounds and increases the degree of ripening, though the use of starter culture is not common (Nour El Daim and El Zubeir, 2010 and El Zubeir *et al.*, 2014).

The objectives of the study are to study the effect of different concentrations of starter culture on the chemical composition and microbial quality of white cheese. It is also meant to determine the optimum starter concentration that produces the best quality cheese.

Raw materials

The raw materials used in this study include: Fresh cow milk brought from University farm, thermophilic lactic starter culture *Streptococcus thermophiles* brought from biotechnology laboratory, Faculty of Agriculture, media, namely potato dextrose agar (PDA) and plate count agar, brought from Food Research Centre, rennet, commercial salt (NaCl) and calcium Chloride, brought from Samabiel Chemical Company.

Cheese manufacture

Twenty liters of milk were heated to 65°C for 30 minutes, cooled to 35°C and then salted by two types of salts (2% w/w sodium chloride and 0.02% w/w calcium chloride). The milk was then divided into four batches of 5 liter each. The first batch was kept without starter culture (as control), the other three batches were treated with starter culture at the concentration of 1.5%, 2%, 2.5%, respectively. Rennet tablets were dissolved in 20-ml distilled water and the formed solution was divided into four batches of 5 ml. each. The mixture was hand stirred for five minutes using a spoon. The batches were then incubated at 40°C and left to develop a curd. After coagulation the curd was cut with an ordinary stainless steel knife to allow for whey separation. The curd was poured into small wooden molds lined with cheese cloth, pressed and left over night.

In the following day, brine solution was prepared by adding salt (6% w/w) to distilled water, heated to 65°C for 30 min and then cooled to 35°C. The fresh curd was immersed into brine solution for 48 hours. Cheese was then transferred to plastic containers and stored at room temperature, for chemical and

microbial analysis, as also previously done by El Owni and Hamid (2007).

Chemical analysis of milk and cheese

Chemical analyses were carried out for raw milk and the cheese. Titratable acidity was determined according to AOAC (1990). Fat content was determined by Gerber Method according to AOAC (1990). Total solids content was determined according to the modified method of AOAC (1990). The protein content was determined by Kjeldahl method as described by AOAC (1990). The moisture content of cheese was determined by the method described by Nour El Diam and El Zubeir (2010).

Before carrying out the microbial examination the glassware were sterilized in a hot dry oven at 160° C for 3 hours. Culture media were prepared: plate count agar to determine the total bacterial count and potato dextrose agar (PDA) for the enumeration of yeasts and molds. Then the serial dilution was prepared. The total viable count was carried out using the pour plate method as described by Kats and Pollan (2012). The mold and yeast enumeration was carried out according to Kats and Pollan (2012).

Sensory evaluation

Ten untrained panelists have tested the produced cheese to evaluate taste, color, flavor, body and texture, and overall acceptability.

Statistical analysis

The data were analyzed using (ANOVA) in completely randomized design. Mean separation was carried out using Duncan multiple range test according to statistical analysis system suggested by Bylund, (2005).

Results and discussion

Coagulation time

As shown in Table 1 the coagulation time for the applied procedure varied between 64 and 75 minutes with an average of 70 minutes, while coagulation time in traditional method

varied between 120 and 180 min. depending on the quantity of added salt prior to renneting (Robinson, 2009).

The addition of starter culture in milk in this study and reduction of the quantity of added salt to 2% (w/w) has resulted in shortening of the coagulation time as compared to the traditional procedure, Asher (2015) obtained similar result.

Yield

Table 1 presents the yield of white soft cheese made using different concentrations of starter culture. The highest yield (13.5%) was obtained in cheese made from the milk treated with 2.5% starter culture while the lowest yield (9.61%) was obtained from the cheese made without starter culture addition. The effect of addition of starter culture in increasing the yield is clear in these results and the results of other authors (Nour El Diam and El Zubeir, 2010; El Owni and Hamid 2007 and Abdalla *et al.*, 2012).

The effect of starter culture on chemical composition of cheese

Moisture content

The data in Table 2 presents the effect of starter culture (0.0, 1.5, 2.0 and 2.5%) on the moisture content of white soft cheese. The effect of addition of starter culture was found to be highly significant ($P < 0.01$). The highest moisture content (69.17%) was obtained in cheese treated with 2.5% (w/w) starter culture and the lowest moisture content (56.15%) was obtained from cheese made without addition of starter culture. The moisture content of the cheese was relatively similar to the values 61.2, 54.2 and 61.6% which were obtained by Warsama *et al.* (2006).

Titrateable acidity

The data in Table 2 presents the effect of the different rates of starter culture (0.0, 1.5, 2.0 and 2.5%) on the acidity of white soft cheese. The acidity of cheese was highly significantly ($P < 0.01$) affected by the addition of starter cultures. The highest acidity (0.32%) was

obtained in cheese made with addition of 2.5% starter culture, while the lowest acidity (0.22%) was obtained in cheese made without starter culture (zero starter culture) Bylund (2005) and Asher (2015) and Abdalla *et al.* (2013) obtained similar results. Increasing the rate of starter culture increased the acidity. Fox (2003) reported that the titratable acidity was in the range of 0.162 to 1.895% when they manufactured Domiati cheese using calf rennet. These values were relatively similar to that obtained in this study.

Fat content

The data in Table 2 shows the effect of the different rates of starter culture (0.0, 1.5, 2.0 and 2.5%) on the fat content of white soft cheese. The fat content was highly significantly ($P<0.01$) affected by the addition of starter culture. The highest fat content (27.6%) was obtained in the cheese made without adding starter culture (zero starter culture) while the lowest fat content (21.0%) was found in cheese made with addition of 2.5% starter culture. The addition of starter culture decreased the fat content. Asher (2015) found that the average fat content of commercial Gibna-Beyda was 14%. while Idris and Alhassan (2010) reported a fat content of 12.65%. These values were lower than those obtained in this study. Obviously the fat content of the cheese is related to the fat content of the original milk as well as to the moisture content of the cheese. The variation in the fat content in this study was due to the addition of starter culture, which increased the moisture content, thus decreased the total solids and fat content, Nour El Diam and El Zubeir (2010) obtained a similar result .

Total solids content

Table 2 showed that the total solids content was highly significantly ($P<0.01$) affected by the addition of starter culture. The highest total solids content (43.77%) was found in cheese made without addition of starter culture and the lowest (31.8%) was found in cheese treated with 2.5% starter culture. The average of the total solids content was 36.75%. These values were significantly different from those obtained by Ibrahim (1999) who reported a range of 39.4 – 45.5%, Bylund who reported a range of 40.3 – 46.7% and Asher who reported

a range of 38.8 – 44.9%. These values are higher compared to that obtained in this study, and the difference was claimed to be due to the increase of moisture content which affect the curd concentration. Winstein (2017) obtained values similar to that obtained in this study.

Total protein content

The data in Table 2 presents the effect of starter culture (0.0, 1.5, 2.0 and 2.5%) on the total protein content of white soft cheese. The total protein content of cheese was highly significantly ($P<0.01$) affected by the addition of starter culture. The highest total protein content (15.0%) was obtained in the cheese made without addition of start culture, while the lowest protein content (9.41%) was obtained in the cheese made with 2.5% starter culture, average value was 12.36%. Ador kour (1992) found that the average total protein of fresh white soft cheese was 13.77%, Fox (2003), Tannahil (2008) and Winstein (2017) reported total protein content in the range of 10.4 – 16.6%, these values were relatively similar to those obtained in this study. Abdel Razig (1996) reported that the total protein of fresh white cheese was 17.79%, and Bylund (2005) reported a value of 16.9% for total protein of fresh white cheese, these values are higher than the value obtained in this study.

Microbial quality

Total bacterial count

The results in Table 3 present the effect of different rates of starter culture (0.0, 1.5, 2.0 and 2.5%) on the total bacterial count of white soft cheese. The total bacterial count was found to be highly significantly ($P<0.01$) affected by the addition of starter culture. The highest bacterial count (4.1 10⁶) was obtained in cheese used 2.5% starter culture and the lowest bacterial count was obtained in cheese made without adding starter culture. The results obtained in this study disagreed with that of El Owni and Hamid (2009) who found that the viable bacterial count of the cheese made in the laboratory (3.5×10^8) was higher than the viable bacterial count of the fresh market cheese (9.5×10^5). The obtained results agreed with that of Doyle (2007) who used

starter culture in processing of the "fetta" cheese.

Yeast and mould count

The results in Table 3 shows the total yeast and mould count. The highest yeast count was obtained in the cheese made with addition of 2% starter culture and the lowest was found in cheese made without adding starter culture. The results in Table 3 revealed the absence of mould (no mould growth). The results obtained in this study were relatively similar to those obtained by El Owni and Hamid (2009) who found that the average yeast count in the fresh cheese varied between 3 10⁴ /g and 8.9 10⁶/g and the mould count varied between 1 10²/g and 3 10²/g.

Organoleptic properties of white soft cheese

The results in Table 4 present the organoleptic properties of white soft cheese made by addition of different rates of starter culture (0.0, 1.5, 2.0 and 2.5%). Generally all cheese samples to which starter culture was added at any rate scored well. Cheese samples made with addition of 1.5% starter culture had the best score, followed by the cheese made using 2% starter culture, compared to control cheese

and cheese made by 2.5% starter culture. According to the panelists who judged the quality of cheese made in this study, the cheese is of high quality, it has good color and smooth but firm body and texture with better consistency and good flavor. However, the obtained results disagreed with those obtained by El Zubeir *et al.* (2014) who found that the cheese developed acceptable flavor and acid taste after two weeks of storage, that was attributed to low bacterial count of heat treated milk which resulted in slower acidity and flavor development. The results in this study agreed with the results obtained by Alcamo (2003) and Doyle (2007). Fresh cheese from heated milk was superior to that made from raw milk with regard to body and texture, while during ripening raw milk cheese was superior to that made from heated milk. Asher (2015) reached the same.

The results obtained in this study are in agreement with those obtained by Fox (2003) who reported that good quality fresh cheese may be obtained from pasteurized whole milk, 1% *Streptococcus lactic* and 0.75% Enterococcus as starter culture.

Table 1: The coagulation time and yield of cheese samples made by different concentrations of starter cultures

Sample	Coagulation time (min)	Yield (%)
A - Control	189	9.61
A1	76	11.82
A2	70	12.33
A3	64	13.51

A Cheese made without addition of starter culture (control).
 A1Cheese made with addition of 1.5% starter culture.
 A2Cheese made with addition of 2.0% starter culture.
 A3Cheese made with addition of 2.5% starter culture

Table 2: The effect of different concentrations of starter culture on the chemical composition of white soft cheese

Component (%)	The concentration of starter culture			
	0 %	1.5 %	2.0 %	2.5 %
Moisture	56.15d	60.11c	61.11b	69.17a
Fat	27.60a	26.30b	25.00c	21.00d
Acidity	0.22d	0.25c	0.29b	0.32a
Protein	15.00a	14.00ab	13.70b	8.40d
Total solids	43.77a	40.11b	39.17c	31.80d

Means within the raw bearing the same superscript letters are not significantly different (P>0.05).

Table 3: The effect of different concentrations of starter culture on the total microbial count of white soft cheese

The concentration of starter culture				
Microbial count	0.0 %	1.5 %	2.0 %	2.5 %
Bacteria	2.3*104b	4.1*105b	4.4*105b	4.1*106a
Yeast	8.5*104b	6.0*105a	1.7*105b	1.2*105b
Mould	0	0	0	0

Means within the same raw bearing the same superscript letters are not significantly different ($P \leq 0.05$).

Table 4: The effect of different concentrations of starter culture on organoleptic quality of white soft cheese

The concentration of starter culture				
Parameters	0.0 %	1.5 %	2.0 %	2.5 %
Color	8.37a	8.70a	8.07a	8.05a
Flavor	5.87b	8.07a	7.57a	6.20b
Texture	6.57c	7.97a	7.30a	5.87c
Acceptability	6.84c	8.18a	7.71b	6.74c

Means within the same raw bearing the same superscript letters are not significantly different ($P > 0.05$).

Conclusion

It was found that the use of starter culture in the processing of white soft cheese caused reduction in coagulation time and increased the yield with increasing rate of starter culture. The chemical composition of white soft cheese (fat, protein, total solids) increased with decreasing the rate of starter culture except for the acidity and the moisture content. Also, it was found that the Sudanese cheese showed the highest quality and the least microbial count at the lower rate of starter culture addition. Hence

It is recommended to use a low concentration of starter culture to produce white soft cheese of good constitution and high acceptability. Furthermore, future studies on the subject area should study the effect of different types of starter cultures on chemical composition and quality of white soft cheese.

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