PJN
ISSN 1680-5194
ansinet.com/pjn

PAKISTAN JOURNAL OF NUTRITION

Science Alert
scialert.net

ANSInet
an open access publisher
http://ansinet.com

OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2021.96.100

Research Article
Nutritional Evaluation and Microbiological Analysis of White Cheese (Gibna Mudaffara) produced in North Kordofan State, Sudan

Asmahan Azhari Ali Mohammed

Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, P.O. Box 6622, Buryadah 51452, Saudi Arabia

Abstract

Objective: The study was carried out to compare the production and composition of Sudanese white cheese (Gibna Mudaffara) in four different localities in North Kordofan states. **Materials and Methods:** A total of 24 samples of white cheese were collected from four cities of North Kordofan. The samples were characterized for their chemical and microbial properties. Data were analyzed using the SPSS software. **Results:** Significant ($p<0.05$) variations were observed in the chemical composition and microbial load of the cheese samples although the production techniques were slightly different from each other. The average chemical composition of the cheese gave the following results: 52.88% total solids, 23.8% fat, 20.4% crude protein, 0.37% water soluble protein, 5.33% ash and 1.057% titratable acidity. The total viable bacteria count was the highest in samples collected from EL Rahad city, while the highest Coliform bacteria counts was recorded in Mudaffara cheese samples obtained from Kazgail city. The total viable bacteria, Coliform bacteria and Staphylococci counts was the lowest in the sample obtained from Abuharaz city. **Conclusion:** A significant difference in the chemical composition and microbial load was observed in the cheese samples. The yeast, mold, *Staphylococcus aureus*, total viable count and coliform bacteria was the highest in the Mudaffara cheese samples.

Key words: Gibna Mudaffara, North Kordofan, Sudan, cheese production, yeast, mold, *Staphylococcus aureus*

Citation: Asmahan Azhari Ali Mohammed, 2021. Nutritional evaluation and microbiological analysis of white cheese (Gibna Mudaffara) produced in North Kordofan state, Sudan. Pak. J. Nutr., 20: 96-100.

Corresponding Author: Asmahan Azhari Ali Mohammed, Department of Food Science and Human Nutrition, College of Agriculture and Veterinary Medicine, Qassim University, P.O. Box 6622, Buryadah, 51452, Saudi Arabia Tel/Fax: (016)3800882

Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Sudan has one of largest livestock populations in Africa. It makes a major contribution to the national economy and export revenue. Traditional dairy products are not only economically important but they also represent a cultural heritage for the production area. Knowledge of microbial communities may help in the specification and characterization of these products. To date, few studies are conducted on Sudanese dairy foods. Important protocols and procedures for safety, storage and production of dairy products must be taken into account[1].

In Sudan, cheese is produced throughout the country, particularly in Eldueim, White Nile State; Elobied, North Kordofan State; Nyala, South Darfur State and other locations[1]. However, in the rural areas of Sudan, cheese production is the most commonly practiced method of preservation of surplus milk, especially during the rainy season when milk is relatively plentiful[1,2]. Traditional Sudanese fermented foods are the main source of nutrition for rural and urban people. Dairy products help in boosting economic growth, finance and business[3]. Sudanese cheese is a traditional product made from raw milk and without the use of starter culture with added salt (6-20%) and is usually packed in plastic containers, a practice that leads to deterioration of quality[4]. This high salt content (6-20%) may have an immediate impact on health and blood pressure[5]. Salt acts as a preservative and protect cheese from rapid deterioration before ripens[6]. Mudaffara cheese is a braided, un-matured semi-hard cheese from the Mediterranean region with a close texture, yellowish color, slightly acidic and salty taste that is popular among Sudanese rural communities. Rennet or rennet extract is added to produce a firm coagulum in four to six hours. Ripening takes place while the cheese is immersed in whey. The purpose of coagulation is to catalyze the conversion of liquid milk into gel using various proteases[7].

In Sudan, cheese making is the main conservation method for excess milk in rural areas particularly during the rainy season when plenty of milk is available and about 152,000 tons of cheese is produced annually[2] and accordingly many types of cheese are produced throughout the country. Of them, braided cheese locally known as Muddaffara is now being produced in Sudan. Muddaffara cheese is among the most popular cheese in Sudan and other Middle Eastern countries. It is estimated that about 7500 t of Muddafara cheese is manufactured in Sudan each year and this cheese is sold in the local markets[8]. Cow milk or sheep milk or a mixture of cow, sheep and goat milk is used to prepare Mudaffara cheese[9]. Increasing demand of Mudaffara cheese in Sudan and its short shelf life at room temperature (15 days), make it so important to enhance its taste and quality. No previous studies have been carried out to investigate the nutritional value and microbiological characteristics of white cheese (Gibna Mudaffara), therefore, the present study was conducted to evaluate the nutritional value, chemical and microbiological composition of Modaffara cheese produced in Sudan.

MATERIALS AND METHODS

Collection of samples: North Kordofan is one of the 18 states of Sudan. It has an area of 185,302 km^2. Twenty-four samples were collected from four cities (El Obaied, El Rahad, Kazgail and Abuharaz) in North Kordofan State.

Chemical analysis of Gibna Mudaffara samples: Gibna Mudaffara were tested for titratable acidity, total solids, crude protein and ash content in accordance with AOAC[10] guidelines. Soluble protein was determined according to the procedure described by Ling[11] while salt content was estimated according to the method described by IDF[12]. The amount of volatile fatty acids was measured according to the procedure described by Kosikowski's[13]. The fat content was evaluated according to the procedure described by Foley *et al.*[14].

Microbiological analysis of cheese samples: Samples were maintained aseptically under refrigerated condition (4°C) before being serially diluted by adding 25 g of Gibna samples to 225 mL of sterile peptone water in a clean 500 ml sterile flask and shaking to generate a 10^{-1} dilution. For enumerating diverse groups of spoilage and harmful bacteria, appropriate dilutions were surface plated on appropriate agar plates[15].

Aerobic colony bacterial count (ACC): The whole bacteria count was determined using plate count agar medium (2006) as described by Laird *et al.*[16] and Ramakant[17].

Coliform bacteria count: To enumerate coliforms and *E. coli*, Violet Red Bile Agar (VRBA, Oxoide) and Eosin Methylene Blue Agar (EMB, Oxoide) Agar medium were used. For coliforms enumeration the plates were incubated at 37°C for 48 h while the plates carrying E. coli were incubated at 44°C for 24 and 48 h[15].

***Staphylococci* count:** Only 0.1 mL of the tested samples from the prepared dilutions was transferred and lightly spread at the floor of mannitol salt agar medium (OXOID, Hampshire,

United Kingdom). Inoculated plates were incubated at 37°C for 48 h and Staphylococci counts per g of examined product was calculated and recorded[15].

Enumeration of molds and yeasts: Sabouraud dextrose agar medium was used for the enumeration of yeasts and molds count as described by Harriagan and McCance[15].

Statistical analysis: This study used a Completely Randomized Design. All statistical analyses were performed using the Statistical Package for Social Science (SPSS)[18] version 10.0 for windows (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

The highest total solids content was recorded for cheese samples obtained from El Rahad (North Kordofan) which was significantly higher ($p<0.001$) than those of the other cheese samples obtained from other three areas. The total solids contents of most cheese samples obtained from El Obaied, Kazgali and Abuharaz showed non-significant variations ($p>0.05$).

The highest protein content, recorded for the cheese sample from El Rahad and Kazgail, while the lowest was observed in the cheese sample obtained from Abuharaz city. However, no significant variations were found in protein contents of the cheese samples between producers in El Obaied and Abuharaz.

The highest water-soluble protein content was observed in cheese sample that obtained from Kazgail city, whilst the lowest was recorded for a cheese sample obtained from El Rahad. Enormous ($p<0.001$) variation was discovered in soluble protein contents of the cheese in special areas.

The ash content for the cheese sample from El Rahad was the highest, while the lowest was for a cheese sample from Abuharaz. The acidity of cheese samples from El Rahad was significantly higher ($p<0.001$) than those of the other cheese samples. The lowest acidity value was recorded for the cheese sample obtained from El Obaied city, higher salt contents was found in the cheese sample obtained from El Rahad city while, the lowest salt contents was recorded in the Kazgail city (Table 1). Variations were observed in fat contents of the cheese in different areas. The results were not in accordance with those reported by Elkhider[19] and Topcu and Saldamli[20] who found 12.8 and 11.79% fat (35.45% of dry matter), respectively. The high average fat contents in this study could be due to high fat contents of the milk used for cheese making. Average protein contents of the collected cheese samples was 20.41%.

These results agree with a previous study conducted by Abdalla[21]. However, these results disagree with those of Ceylan *et al.*[22]; Lemya *et al.*[23] and El Owni and Hamid[2]. Average water soluble protein contents of collected cheese sample was 0.36%. This finding is lower than the result of a previous study conducted by Tarakci and Kucukoner[24].

In several areas, variations were observed in fat contents of the cheese. The findings of the present study agree with the results of Nuser[25]. From the results it is obvious that the fat, protein, total solids and moisture contents of white cheese (Gibna Mudaffara) satisfied the Sudanese standard for cheese while the acidity didn't satisfy the quality.

Table 2 shows that total viable count was the highest in the Gibna Mudaffara samples obtained from El Rahad and the lowest in the samples which were obtained from Abuharaz. The highest Coliform bacteria count was recorded for the Mudaffara cheese samples from Kazgail, while the lowest was found in cheese samples obtained from Abuharaz. However, significant variations ($p<0.001$) were found in Coliform counts of the cheese samples among producers in El Obaied and Abuharaz and El Rahad city. The highest molds and yeast counts were recorded for cheese samples obtained form Abuharaz, while the lowest was recorded for a cheese samples from El Obaied. Molds and yeast counts of the cheese were significantly ($p<0.001$) different in different areas. The difference in the chemical composition and microbial load could be attributed to variation in the chemical composition of raw milk used for cheese manufacturing or difference in manufacturing process and marketing methods, since there is no standard procedure for cheese manufacturing in Sudan

Table 1: Chemical composition of the cheese (Gibna Mudaffara) samples

Samples	TS (%)	Fat (%)	CP (%)	SP (%)	Ash (%)	TA (%)	Salt (%)
El Obaied	54.27^{bc}	22.66^{abc}	20.67^{cdef}	0.37^{bcd}	6.57^{abc}	1.41^{abc}	5.80^{b}
Kazgail	53.85^{bc}	26.18^{a}	21.13^{bcdef}	0.41^{bcd}	3.87^{de}	1.42^{ab}	4.30^{bcd}
El Rahad	56.01^{ab}	23.66^{abc}	21.03^{bcdef}	0.35^{bcd}	6.73^{ab}	1.50^{ab}	5.47^{b}
Abuharaz	48.67^{cde}	22.83^{abc}	19.17^{def}	0.55^{bcd}	3.03^{de}	1.47^{ab}	8.63^{a}
Average	52.88	23.8	20.4	0.37	5.33	1.057	6.71
Level of significance	***	**	***	***	***	***	***

Means within the column bearing different superscripts are significantly different ($p< 0.01$). ***Means highly significant at $p<0.001$, TS: Total solids, CP: Crude protein, SP: Soluble protein

Table 2: Microbiological content of the cheese (Gibna Mudaffara) samples

Parameter (Log_{10} CFU mL^{-1})	El Obaied	Kazgil	El Rahad	Abuharaz
Total viable bacteria count	4.700±0.013[b]	4.600±0.013[c]	4.800±0.014[a]	1.294±0.021[d]
Coliform bacteria count	3.935±0.014[c]	4.227±0.015[a]	4.157±0.015[b]	0.214±0.047[d]
Staphylococci count	2.894±0.024[b]	2.753±0.026[c]	2.994±0.025[a]	0.621±0.049[d]
Molds and yeasts	0.789±0.023[d]	0.843±0.026[c]	1.810±0.025[b]	2.360±0.073[a]

Microorganisms play an important role in the deterioration of dairy products and in the ripening of some types of cheese[25]. The spoilage organisms in cheese and dairy products are coliforms, yeasts and molds, propionic acid bacteria, fecal *streptococci*, *lactococic* lactic acid and *psychrotrophic* bacteria[22]. The spoilage microorganisms differ greatly in dairy products due to the selective effect of practices followed in production, formulation, processing, packaging, storage, distribution and handling[26]. Raw milk may contain a wide variety of pathogenic organisms. They may be derived from an infected (mastitic) udder, the faeces or other excreta of infected cows or symptomless (carrier), cows, human sources, a contaminated environment or dairy equipment. The group includes *Staph aureus*, *Streptococcus* spp, *Salmonella*, *E. Coli*, *Listeria monocytogenes*, etc. If pathogens survive during cheese manufacturing process, it may result in food poisoning due to the ingestion of cheese contaminated with pathogenic organisms and their enterotoxins. Mold species are essential for ripening of specific varieties of cheese but mold growth on most cheeses is undesirable. It spoils the appearance, can impart musty flavor and may produce mycotoxins[27].

Coliform contamination of cheese, particularly fecal coliforms, is an indication of direct or indirect fecal contamination and is seen as a mirror of the degree of non-compliance with many hygiene standards during processing and marketing[28]. Osman[4] examined the microbiological properties of Sudanese white cheese and found that the total count of bacteria, coliforms and molds, as well as the yeasts of the cheese samples, increased significantly at the beginning of storage ($p \leq 0.05$) and the time of storage decreased towards the end of the year, only *Staphylococcus aureus* was detected on day zero and disappeared completely during the storage period. Salmonella were not found. Ceylan *et al.*[22] examined the microbiological quality of white cheese and found that the average number of coliforms was 5.99 log CFU g^{-1}; the high content of coliforms was attributed to post-contamination during storage. Recently, due to increase in population, the cheese (Gibna Mudaffara) industry has become a common sight without supervision or quality, Sudanese white cheese is delivered to the market immediately after processing under inadequate conditions such as poor handling technique, inappropriate packaging materials and lack of adequate storage facilities. However, dairy products including cheese must be safe, acceptable and should meet consumer's satisfaction[2,29]. Different factors that influence the quality and nutritive value of white cheese include composition of food materials, the natural of the compounds, the type of packaging system and the preservative used[30].

CONCLUSION

Both rural and urban residents in Sudan rely on traditional fermented foods as their primary source of sustenance. Dairy products accelerate the economic growth. In Sudan, white cheese is produced under inadequate conditions. Its quality is neither checked nor controlled. Lack of adequate storage facilities, inappropriate packaging material and poor handling technique increase the risk of spoilage of dairy products.

REFERENCES

1. Mohamed, N.N.I. and I.E.M. El Zubeir, 2007. Evaluation of the hygienic quality of market milk of Khartoum State (Sudan). Int. J. Dairy Sci., 2: 33-41.
2. El Owni, O.A.O. and O.I.A. Hamid, 2008. Effect of storage period on weight loss, chemical composition, microbiological and sensory characteristics of sudanese white cheese (*Gibna bayda*). Pak. J. Nutr., 7: 75-80.
3. Salih, A.M.M., S.M. El-Sanousi and I.E.M. El-Zubeir, 2011. A review on the Sudanese traditional dairy products and technology. Int. J. Dairy Sci., 6: 227-245.
4. Osman, M., M. Abdalla and S.N. Mohamed, 2009. Effect of storage period on chemical composition and sensory characteristics of vacuum packaged white soft cheese. Pak. J. Nutr., 8: 145-147.
5. Lifton, R.P., A.G. Gharavi and D.S. Geller, 2001. Molecular mechanisms of human hypertension. Cell, 104: 545-556.
6. Taormina, P.J., 2010. Implications of salt and sodium reduction on microbial food safety. Crit. Rev. Food Sci. Nutr., 50: 209-227.
7. Troch, T., E. Lefebure, V. Baeten, F. Colinet, N. Gengler and M. Sindic, 2017. Cow milk coagulation: Process description, variation factors and evaluation methodologies. A review. Biotechnol. Agron. Soc. Environ., Vol. 21. 10.25518/1780-4507.13692

8. Altahir, M.O., E.A. Elgasim and I.A.M. Ahmed, 2014. Ripening of Sudanese braided (muddaffara) cheese manufactured from raw or pasteurized milk: Effect of heat treatment and salt concentration on the physicochemical properties. Int. J. Food Sci., Vol. 2014. 10.1155/2014/698263.
9. El-Owni, O.A.O. and S.E. Osman, 2009. Evaluation of chemical composition and yield of mozzarella cheese using two different methods of processing. Pak. J. Nutr., 8: 684-687.
10. AOAC, 1990. Official Methods of Analysis. 15th Edn., Association of Official Analytical Chemists, Washington, DC., USA., pp: 200-210.
11. Ling, E.R., 1963. A Textbook of Dairy Chemistry. 3rd Edn., Vol. 2, Chapman and Hall Ltd., London.
12. IDF., 1986. Cheese and processed cheese products-determination of fat content-Gravimetric method (reference method). International IDF Standard 5B:1986, International Dairy Federation, Brussels, Belgium.
13. Kosikowski, F.V., 1977. Cheese and Fermented Milk Foods. 2nd Edn., Edwards Brothers Inc., Ann Arbor, MI., pp: 448.
14. Foley, J., J. Buckley and M.F. Murphy, 1974. Commercial Testing and Product Control in the Dairy Industry. University College Cork, UK., pp: 17-20.
15. Harrigan, W.F. and M.E. McCance, 1976. Laboratory Methods in Food and Dairy Microbiology. 1st Edn., Academic Psress, London, pp: 25-29.
16. Laird, D.T., S.A. Gambrel-Lenars, F.M. Scher, T.E. Graham and R. Reddy, 2004. Microbiological Count Methods. In: Standard Methods for the Examination of Dairy Products, Wehr, H.M. and J.F. Frank (Eds.)., 17th Edn., Chapter 6, American Public Health Association, Washington, DC., USA. ISBN-13: 978-0875530024, pp: 153-186.
17. Ramakant, S., 2006. Production Processing And Quality Of Milk Products. IBDC. International Books Distributing Co., India.
18. SPSS Inc., 1998. SPSS Base 8.0 for Windows User's Guide. SPSS Inc., Chicago, IL., USA.
19. Elkhider, I.E.A., 2017. Physicochemical and sensory characteristics of Sudanese lowfat cheese during storage period. IOSR J. Agric. Vet. Sci., 10: 06-10.
20. Topcu, A. and I. Saldamli, 2006. Proteolytical, chemical, textural and sensorial changes during the ripening of Turkish white cheese made of pasteurized cows milk. Int. J. Food Prop., 9: 665-678.
21. Abdalla, M.O.M. and S.M. Nusr, 2009. Effect of cooking and vacuum packaging on chemical composition and sensory characteristics of white soft cheese. J. Applied Sci. Res., 5: 1421-1424.
22. Ceylan, Z.G., H. Turkoglu and K.S. Dayisoylu, 2003. The microbiological and chemical quality of sikma cheese produced in Turkey. Pak. J. Nutr., 2: 95-97.
23. Lemya, M.W., I.E.M. El-Zubeir and O.A.O. El-Owni, 2006. Composition and hygienic quality of Sudanese white cheese in Khartoum North markets (Sudan). Int. J. Dairy Sci., 1: 36-43.
24. Tarakci, Z. and E. Kucukoner, 2006. Changes on physicochemical, lipolysis and proteolysis of vacuum packed Turkish Kashar cheese during ripening. J. Central Eur. Agric., 7: 459-464.
25. Irlinger, F. and J. Mounier, 2011. Microbial interactions in cheese: implications for cheese quality and safety. Curr. Opin. Biotechnol., 20: 142-148.
26. Sperber, W.H. and M.P. Doyle, 2009. Compendium of the Microbiological Spoilage of Foods and Beverages. Springer, New York, USA., ISBN-13: 9781441908261, Pages: 369.
27. Lee, S.K., S. Anema and H. Klostermeyer, 2004. The influence of moisture content on the rheological properties of processed cheese spreads. Int. J. Food Sci. Technol., 39: 763-771.
28. Jay, J.M., M.J. Loessner and D.A. Golden, 2008. Modern Food Microbiology. 7th Edn., Springer, Boston, MA, Pages: 790.
29. Hamid, O.I.A., O.A.O. El Owni and M.T. Musa, 2008. Effect of salt concentration on weight loss, chemical composition and sensory characteristics of sudanese white cheese. Int. J. Dairy. Sci., 3: 79-85.
30. Mohamed, O.A.E. and I.E.Y.M.E., Zubeir, 2018. Comparative study on chemical and microbiological properties of white cheese produced by traditional and modern factories. Ann. Food Sci. Technol., 19: 111-120.