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PHYSICO-CHEMICAL AND MICROBIAL QUALITY OF LOCALLY AVAILABLE SOFT-WHITE CHEESE (KESONG PUTI) IN LAGUNA, PHILIPPINES

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ABSTRACT

Soft-white cheese, also known as kesong puti, is a locally produced cheese popularized in Laguna, Philippines. This study aimed to assess the physico-chemical and microbial quality of kesong puti produced by home-based processors, comparing them to an institutional producer. Protein, fat, moisture, ash, and pH were analyzed from three batches of kesong puti from four different producers. Duplicate tests per batch were conducted. Microbial analyses were performed to determine the total plate count (TPC), total coliform (TC), and *Escherichia coli* (EC) levels. Results showed that the institutional producer had significantly higher (p<0.05) fat content (16.14%) and pH (6.62) compared to the home-produced kesong puti, which ranged from 10.21-11.79% for fat and 5.73-5.99 for pH. The TPC, TC, and EC also exhibited highly significant (p<0.01) differences, with higher microbial counts in the home-produced kesong puti, exceeding the limits set by the Food and Drug Administration. Production practices, milk sources, and handling methods likely contribute to these differences. The study underscores the importance of implementing quality control measures in kesong puti manufacturing and distribution, especially for home-based processors. The data generated from this study can serve as a basis for establishing ordinances for regular monitoring of kesong puti produced by home-based processors.

Keywords: *Kesong puti*, microbial quality, physico-chemical quality, soft-white cheese

INTRODUCTION

Soft-white cheese, or *kesong puti* is an indigenous unripened cheese of the Philippines, usually made from unskimmed carabao's (*Bubalus bubalis carabanensis*) milk. Kesong puti has a very palatable, smooth texture and a pleasant aroma. It can be stored for two days at room temperature (28°C to 30°C) or for one week when refrigerated at 5°C to 10°C but it is usually consumed right after it is processed (Moreno & Emata, 2021). However, as soft-white cheese processing is done at home, it is usually characterized by variations in product quality,

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the efficiency of processes used, and even the safety of foods. Moreover, scientific studies are still required for the understanding and improvement, if necessary, of the product.

Santa Cruz, Laguna originated the production of soft-white cheese in the Philippines, which also celebrates the annual "Kesong Puti Festival" (Rivera, 2021). Soft-white cheese from Laguna is traditionally sold wrapped in banana leaves and has a shelf life of about a week. The *kesong puti* industry is in many municipalities throughout Luzon, including Laguna, Cavite, and Bulacan, as well as Cebu, Leyte, and Samar in the Visayas They differ in some parameters such as coagulant type, coagulant to milk ratio, salt content, whey draining process, and brining (Aquino *et al.* 2011). Other countries also have their version of soft-white cheese. Jben is a soft white cheese made from goat milk that has been popular in Morocco for centuries (Sarhir *et al.*, 2022). In Egypt and the Arab world, low-fat white soft cheese made from buffalo skimmed milk is one of the most popular types of cheese (Abo-Elwafa *et al.*, 2015; Moneeb *et al.*, 2022). The major type of cheese produced in Jordan is soft white cheese, which is usually made from ewe or goat milk (Haddad & Yamani, 2017).

Kesong puti production is usually done on a kitchen scale. Although manufacturers need to ensure health and sanitary permits from the local authorities before they can process the cheese, the quality of these locally available cheeses is understudied. Several factors might affect the quality of kesong puti, including the equipment used during processing, packaging, duration, and the location of where products were displayed. Display carts were commonly located just beside the major thoroughfare in the locality. Additionally, there is an unknown impact on the monitoring of these local producers to ensure the quality of their cheese. Traditional methods of processing soft white cheese usually result in variability in composition and quality (Pesic-Mikuleci and Jovanovic, 2005).

Kisworo and Barraquio (2003) conducted a study on Philippine local white soft cheeses and revealed that the pH of the cheeses ranged from 5.8 to 6.54. The mean moisture content ranges from 57.55% to 67.17%; ash content varies between 2.76% and 3.23%; protein content ranges from 17.60% to 20.53%; salt content is between 1.81% and 2.01%; and fat content ranges from 4.3% to 7.2%. The study of Moreno & Emata (2021) on Filipino white cheese with varying concentrations of calcium chloride, their study resulted in a mean pH of 5.67 to 5.87, titratable acidity of 0.1480 to 0.1680% lactic acid, fat content between 10.71% and 10.84%, protein content ranging from 9.34% to 11.25%, moisture content of 60.97% to 64.97%, and total solids content between 35.03% and 39.03%. In all treatments, coliform and *Escherichia coli* counts were acceptable based on the guidelines issued by the Philippines' Food and Drug Administration for soft and semi-soft cheeses.

Soft-white cheese or *kesong puti* is an in-demand local dairy product that is widely consumed in Laguna. Currently, there are no official standards set by the national or local governments about kesong puti. By conducting this study, the physico-chemical, and microbial properties of kesong puti can be determined. This study will be useful in identifying any potential health risks related to the intake of this cheese as well as improving its general quality. The analysis of kesong puti is critical for guaranteeing the safety and quality of a popular food product in Laguna, Philippines. The data generated from this study can serve as a basis for establishing ordinances for regular monitoring of kesong puti produced by home-based processors.

The study was conducted to streamline the quality of soft-white cheese in Laguna, Philippines. This study will help national and local authorities implement and monitor the quality standard of locally produced soft-white cheese. The local government unit can use the data to adhere to the quality and safety of locally produced soft-white cheese.

This study aimed to assess the physico-chemical and microbial quality of locally available soft-white cheese made from carabao milk sold in Laguna, Philippines. Specifically, this study aimed to compare the quality of kesong puti from home-based processors to that of the institutional producer and determine the adherence of local producers to microbial standards for the product.

MATERIALS AND METHODS

Experimental treatments and design

This study primarily examined the production of kesong puti using carabao milk in the province of Laguna, Philippines. To the best of our current understanding, there exists only one institutional dairy processing facility inside this locality that specializes in the production of white cheese derived from carabao milk. This plant served as our sole producer within the institutional framework.

The decision to choose the three home-based processors was based on their established and recognized reputation and importance in the community as producers of kesong puti. These producers capture a representation of the local, traditional cheese-making practices in the area.

Experimental treatments are kesong puti that were randomly sampled from the identified local processors. Three batches of samples were assessed. Each batch was considered a replicate. The experimental design was a complete randomized design (CRD) with three replications.

Soft-white cheese sample collection

KP1 was bought from an institutional dairy processing plant in Laguna at around 8:30 AM and was transported to the laboratory in less than five minutes. Kesong puti from three local producers (KP2, KP3, KP4) were also bought from established and recognized home-based producers in Laguna at around 7 a.m. and were immediately transported. The samples were kept in a cooler box with ice packs to maintain a consistent low temperature and ensure their quality during a thirty-minute transport to the laboratory. All samples were kesong puti made from carabao milk. There was no survey interview nor documentation on the sources of milk and processing methods. Cheese samples were purchased directly from the home base processors. All samples were bought on the same day and were immediately subjected to laboratory testing. This process was repeated for three consecutive weeks from April to May 2023 to ensure that the cheese samples were processed on different dates.

Sample Preparation

The cheese samples were transferred to a sanitized container. Each kesong puti sample from the different producers was mixed, mashed, and pooled. From the pooled cheese samples, composite samples were transferred to conical tubes for physico-chemical analyses. Guidelines from the Association of Official Analytical Chemists (AOAC, 1990) were followed to determine the fat, protein, moisture, and ash.

For the microbiological analyses, 10 g of kesong puti were aseptically obtained from the pooled samples and transferred to a sterilized 90 ml 2% sodium citrate solution. It was vigorously shaken until the cheese was completely dissolved.

Physico-chemical analyses

Fat content. Two to three grams of cheese were weighed using an analytical balance, wrapped in filter paper, transferred to a foil container, and then dried in an oven overnight at 105°C. The crude fat was extracted using a Soxhlet apparatus. After 16 hours of extraction, the samples were dried in an oven and then weighed.

Protein content. The three batches of kesong puti were mixed, mashed, and pooled. Five to ten grams of samples were weighed. The protein content was measured using the Kjeldahl technique.

Moisture and ash content. One to two grams of kesong puti samples were weighed using an analytical balance and transferred to a crucible. The moisture content was determined by drying the samples in an oven (Precision Scientific Co. Oven) overnight at 105°C. The ash content was determined by incinerating the samples in a furnace (VULCAN™ Benchtop Furnace A-550) at 650°C for five hours.

pH determination. The pH value of the samples was measured on the day they were bought using an APERA Instruments PH60S pH tester. The pH tester was calibrated and measured at room temperature. The probe was inserted directly into the sample, and the pH reading was taken when the value stabilized. Each sample was measured twice.

Microbial analyses

Laboratory preparation. All conical tubes containing peptone water, pipette tips, and other materials needed for microbiological assessment were sterilized in a stovetop autoclave at 15 psi for 15 minutes. The working area was cleaned, sanitized, and disinfected before the experiment. Stock culture (10^0) was made by taking 10 g of the mashed cheese from the pooled sample mixed with 90 ml of a 2% sodium citrate solution. This stock culture was used for serial dilution preparation.

Serial dilution preparation. Serial dilutions of up to 10^{-8} were prepared in sterile buffered peptone water (BPW) (Biomark® Laboratories). From the stock culture, 1 ml was taken and put in a tube containing 9 ml of BPW, this is 10^{-1} dilution. From the 10^{-1} dilution, 1 ml was taken and put in a tube with 9 ml of BPW, this is the 10^{-2} dilution. The procedure was repeated until the desired dilution series was made.

Inoculation and Enumeration. Samples were tested for counts of total aerobic bacteria (TPC), coliform (TC), and *Escherichia coli* (EC). All microbial counts were determined using a specific plate (Compact Dry TC and Compact Dry EC, R-Biopharm®). Dilutions 10^{-5}, 10^{-6}, 10^{-7}, and 10^{-8} were used in plating for TPC and TC, while 10^0, 10^{-1}, 10^{-2}, and 10^{-3} dilutions were plated for EC. Platings were done in duplicate. After plating, all plates were incubated (Memmert Incubator Model 30-1060) at 37°C in an inverted position for 24 hours for TC/EC and 48 hours for TPC. After incubation, plates with colonies 25-250 were used for counting using the formula from the Bacteriological Analytical Manual (BAM) of the United States Food and Drug Association (FDA) (Maturin & Peeler, 2001).

Statistical analysis

One-way analysis of variance (ANOVA) in CRD was used to analyze the qualities of the samples using R Studio version 4.3.0 (2023-04-21 ucrt). Tukey's Honest Significant Test (HSD) was used as the post hoc test to determine which samples were significantly different from each other. The physicochemical analyses were conducted with a predetermined significance level of 0.05, while the microbial analyses were conducted with a more stringent significance level of 0.01. The selection of these alpha levels was made to establish the thresholds for statistical significance in the analysis of the data. The data was presented as Mean ± SD (standard deviation).

RESULTS AND DISCUSSION

Physico-chemical characteristics

The physico-chemical analysis of the four soft white cheeses (KP1, KP2, KP3, and KP4) is listed in Table 1. KP1 served as the control for this study, while the rest are from home-based processors. The results of the physico-chemical analysis indicate that the composition of soft white cheeses varies significantly. These distinctions can be attributed to factors such as the cheese producers' production methods, milk sources, and handling practices. Thermal treatment during processing greatly influences the composition, body, and texture of the cheese. Heat causes the denaturation of milk proteins thus affecting binding capacity for water and other milk components. The higher the temperature of heating, the greater the denaturation would be while binding capacity becomes lower. Heating also causes evaporation of water, thereby concentrating the other milk components. Thermal treatment destroys microorganisms and inactivates enzymes inherent in milk. The data from this study indicates notable disparities in the processing methods employed by cheesemakers, evident through variations in the composition and pH of soft-white cheese. While a lower pH is often associated with the production of acid due to microbial activity (Devlieghere *et al.*, 2013), it is essential to recognize that factors beyond processing methods may also contribute to these pH variations. These factors could encompass variations in milk sources, microbial populations, or environmental conditions, all of which warrant further investigation to comprehensively understand their impact on soft-white cheese quality.

Table 1. Physico-chemical characteristics of the kesong puti (KP) samples

Parameters	KP1	KP2	KP3	KP4
Protein (%)	9.84 ± 0.16^{a}	7.68 ± 0.10^{b}	10.35 ± 0.11^{a}	7.09 ± 0.10^{c}
Fat (%)	16.14 ± 0.61^{a}	11.79 ± 2.42^{b}	10.97 ± 0.31^{b}	10.21 ± 0.54^{b}
Moisture (%)	64.89 ± 0.96^{a}	70.50 ± 3.96^{ad}	71.25 ± 1.70^{bd}	71.18 ± 0.94^{cd}
Ash (%)	2.87 ± 0.16^{a}	2.50 ± 0.33^{a}	2.66 ± 0.43^{a}	2.82 ± 0.18^{a}
pH	6.62 ± 0.12^{a}	5.99 ± 0.09^{b}	5.73 ± 0.20^{b}	5.78 ± 0.24^{b}

The values in each row with different superscripts are significantly different ($p < 0.05$) using the Tukey HSD
KP1 – dairy plant processed-kesong puti

KP2, KP3, KP4 – home-processed kesong puti from 3 known producers

In terms of total or crude protein content, KP1 and KP3 exhibited the highest values with 9.84 ± 0.16% and 10.35 ± 0.11%, respectively. KP2 had a significantly ($p < 0.05$) lower protein content at 7.68 ± 0.10%, while KP4 had the lowest protein at 7.09 ± 0.10%. This is lower compared to the total protein content from Cavite and Santa Cruz, Laguna which ranges from 17.60 to 20.53% (Kisworo and Barraquio, 2003), and from Lumban, Laguna which ranges from 11.49 to 13.14% (Aquino *et al.*, 2011). Differences in milk quality, whey drainage, and processing methods used by the producers could all have an impact on this variation.

For fat content, KP1 showed a significant ($p < 0.05$) difference among the rest, with a value of 16.14 ± 0.61%. KP2, KP3, and KP4, with a fat content of 11.79 ± 2.42%, 10.97 ± 0.31%, and, 10.21 ± 0.54%, respectively, had no significant difference among themselves. The samples' significantly lower fat content than the control might be due to the high moisture content of the home-based kesong puti. This is similar to the results obtained by Aquino *et al.* (2021); in their study, the kesong puti sold in Lumban, Laguna has a lower fat content (approximately 10%) and a higher moisture content than the kesong puti sold in DTRI. The producers did not disclose or provide information about the breeds of the carabaos, which is significant because the breed can greatly influence the fat content of the milk.

Abo-Elwafa *et al.* (2015) studied the soft-white cheese locally sold in Cairo, Egypt, and found that most vendors use vegetable oils only or a mixture of vegetable oil and milk, which resulted in a fat content ranging from 35 to 51%. This is significantly higher than the control they made with 14% fat content, which is also similar to the control from the study of Farrag *et al.* (2017). Hassan *et al.* (2018) also studied the production of soft white cheese, which had a fat content of 13.00 to 15.25%. Similarly, El-Sayed *et al.* (2015) had soft-white cheese with a fat content of 10.5 to 11.1%.

The moisture content varied among the cheeses. KP1 had the lowest moisture content with 64.89 ± 0.96%, while KP2, KP3, and KP4 exhibited higher moisture contents at 70.50 ± 3.96%, 71.25 ± 1.70%, and 71.18 ± 0.94%, respectively. The moisture content of locally available kesong puti in Cavite and Santa Cruz ranges from 57.55 to 67.17% (Kisworo and Barraquio, 2003) while 65.96 to 67.27% in Lumban (Aquino *et al.*, 2011). It can be observed that in this study KP2, KP3, and KP4 had higher moisture content compared to the control and other related literature. KP2, KP3, and KP4 are locally produced or are home-based. Home-based producers typically operate without the controlled environments and standardized processes found in institutional settings. This difference in production conditions could potentially impact the moisture content of kesong puti cheese.

The ash content, which serves as an indicator of the mineral content, exhibited a relatively uniform distribution across the various types of cheeses. The ash contents of all cheeses exhibited a range of 2.50 ± 0.33% to 2.87 ± 0.16%. This indicates that the soft white cheeses' mineral composition was generally consistent. The measured ash content is similar to that of Aquino *et al.* (2011), with an ash content ranging from 2.20 to 2.60%. Kesong puti sold in Cavite and Santa Cruz, Laguna had ash content ranging from 2.76 to 3.23% (Kisworo and Barraquio, 2003).

Regarding pH, KP1 displayed a highly significant difference ($p < 0.01$) with a value of 6.62 ± 0.12, indicating a slightly more alkaline nature. KP2, KP3, and KP4 had lower pH values of 5.99 ± 0.09, 5.73 ± 0.20, and 5.78 ± 0.24, respectively. The pH of KP1 is near the values obtained in the studies of Farrag *et al.* (2017) and Hassan *et al.* (2018) at a pH of 6.80 and 6.41, respectively. The lower pH can be attributed to microbial activity in the cheese produced by home-based processors.

Microbial characteristics

The results of the microbial analysis are presented in Table 2. The total plate count obtained in this study is lower compared to the one obtained in the study of Alper and Nesrin (2013) on fresh white cheese, with a total aerobic mesophilic bacterial count ranging from

5.2 x 10^4 to 5.68 x 10^{11} cfu/g. On the other hand, the present observations are similar to the findings of Nieves *et al.* (2021) and Aquino *et al.* (2011), who obtained a total aerobic count of soft-white cheese ranging from 10^3 to 10^7 cfu/g and 1.4-8.4 x 10^6 cfu/g, respectively. Total plate count of cheese from the dairy plant (7.3 x10^3) slightly exceeds the FDA (FDA Circular No. 2013-010) acceptable limit of 10^3 cfu/g although it is significantly lower than those of the home-based processors (3.9 x10^9, 6.4 x10^7, 8.1 x10^7). All home-processed kesong puti did not meet the FDA standard.

Table 2. Microbial characteristics of the kesong puti samples (cfu/g).

Parameter	KP 1	KP 2	KP 3	KP 4
Total plate count	7.3 x10^{3a}	3.9 x10^{9b}	6.4 x10^{7b}	8.1 x10^{7b}
Total coliform	3.0 x10^{1a}	1.8 x10^{7b}	8.1 x10^{6b}	1.7 x10^{7b}
E. coli	ND^{a}	1.5 x10^{4b}	1.1 x10^{4b}	1.8 x10^{3b}

The values in each row with different superscripts are significantly different ($p < 0.01$) using the Tukey HSD
KP1 – dairy plant processed-kesong puti
KP2, KP3, KP4 – home-processed kesong puti from 3 known producers
ND – not detected
FDA Standards (FDA Circular No. 2013-010): Total Plate Count = 10^3 cfu/g; Total Coliform = 10^3 cfu/g; *E. coli* = 110 cfu/g

A similar trend was obtained in the total coliform counts. Kesong puti from home-based processors had counts ranging from 8.1 x 10^6 to 1.8 x 10^7, which are beyond the acceptable limit for total coliform count in soft cheese from the FDA. On the other hand, kesong puti from the dairy plant had a count of 3.0 x 10^1 which is lower than the maximum acceptable limit.

Based on the FDA limit of 0 for *Escherichia coli* in soft cheese, only the kesong puti from the dairy plant was able to meet the standard. The home-processed cheese had counts of 1.8 x 10^3 to 1.5 x 10^4.

Results showed that kesong puti samples from the dairy processing plant have better microbial quality than the home-processed samples. They are deemed safe for human consumption based on their compliance with FDA microbial standards for soft cheese.

The moisture content and pH data presented in Table 1 support the microbial load data of the kesong puti samples. It was observed that kesong puti from the dairy plant (KP1) has lower moisture content and higher pH value compared with home-processed samples KP2, KP3, and KP4. The higher pH indicates lower microbial activity in the cheese. The microbial count of the kesong puti from the home-based processor was significantly higher than the institutional dairy processing plant kesong puti. This result implies that heat treatment was insufficient in home-based producers. Lower temperatures are used by the home-based processors compared with the dairy processing plant. The lower moisture content of the dairy plant cheese somehow slowed down microbial growth and activity. Microorganisms grow favorably in a high-water activity environment which partially explains the higher microbial load of home-processed kesong puti. Further, the differences between samples are attributed to many factors, which include milk sources, handling, method of processing, and packaging (Aquino *et al.*, 2011). The producer of KP1 is an institutional dairy processing plant that follows Good Manufacturing Practices (GMP) throughout its production. They also practiced pasteurization when making cheese. In addition, their final product is packaged in a closed plastic tub. On the other hand, samples KP2, KP3, and KP4 come from local processors that follow the traditional indigenous procedure of making cheese which probably uses a different thermal treatment. They also sold cheese packed in banana leaves, which can be a source of contaminants. These factors have contributed to the growth of microorganisms, resulting in higher counts compared to KP1.

CONCLUSION

The results showed significant variations in the physico-chemical composition of kesong puti among producers. KP1 cheese has higher fat content but lower moisture than KP2, KP3, and KP3 cheeses. The differences are attributed to the source of raw milk but more so to the processing procedures (*i.e.* thermal treatment) and handling practices of the kesong puti producers. The significantly high pH of cheese coming from the dairy plant processor compared with the home-based processors is evidence of better product packaging and handling. Among the producers, only the dairy processing plant was able to produce kesong puti that adheres to the microbiological standards set by the FDA.

The results highlight the importance of implementing quality control protocols in the production and distribution of kesong puti, with a special focus on home-based processors. The enhancement of kesong puti's quality and safety can be achieved through the implementation of good manufacturing practices, appropriate milk sourcing, and adherence to hygienic handling practices. Consistent monitoring and strict adherence to microbial standards are imperative to guarantee food safety and safeguard consumer welfare. The study also emphasizes the value of standardized manufacturing techniques in kesong puti manufacture.

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