

Chemical and Microbiological Quality Evaluation of Powdered *Etawa* Goat Milk Product

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ABSTRACT

Powdered *Etawa* goat milk products are increasingly developed as shelf-stable dairy products; however, their quality should be evaluated according to the characteristics of the product and the applicable quality requirements. This study aimed to evaluate the chemical and microbiological characteristics of a powdered *Etawa* goat milk product produced by a powdered *Etawa* goat milk processing plant in Yogyakarta and assess its conformity with SNI 2970:2015. The study used a descriptive observational design and a single product sample obtained from one production batch. The product was produced using an open-pan crystallization process involving the addition of refined sugar and seed powder. Proximate characteristics, heavy metals, prohibited chemicals, other chemical contaminants, and microbiological parameters were evaluated using laboratory analyses and compared descriptively with SNI 2970:2015. Moisture (1.54%) and fat (29.12%) complied with the specified requirements, whereas protein content (16.87%) was substantially lower than the 32% minimum specified for milk powder. Pb, Cd, Sn, Hg, As, melamine, alcohol, caffeine, formaldehyde, borax, methanyl yellow, and rhodamine B were not detected or were negative, while quinine was reported as <6 mg/kg. *Salmonella* spp. and *Staphylococcus aureus* were not detected. The results indicate satisfactory chemical and microbiological safety for the analyzed batch; however, the low protein content should be interpreted in relation to the product formulation and the applicability of the milk-powder standard to this sugar-crystallized product. Because only one batch was evaluated without analytical replication, the findings should not be generalized to all production batches or commercial products.

1. Introduction

Milk is a nutritious food that contributes significantly to meeting the needs for protein, fat, vitamins, minerals, and various bioactive compounds necessary to support human health [1]–[3]. As public awareness of healthy food consumption patterns increases, demand for dairy products with high nutritional value and functional benefits continues to rise [4], [5]. In recent years, goat's milk has received increasing attention due to its unique nutritional characteristics, including smaller fat globule size, more easily digested protein, and the content of various bioactive components that have the potential to provide health benefits [6], [7]. Furthermore, goat's milk is also reported to have good digestibility and has the potential to become an alternative dairy product for certain consumer groups [8]. To increase added value, extend shelf life, and facilitate storage and distribution, goat's milk has

been developed into various processed products, one of which is powdered milk [9], [10]. Compared with fresh milk, powdered goat's milk has better storage stability, is more practical to handle, and retains most of its nutritional characteristics when produced using appropriate processing methods [11], [12]. However, powdered goat milk products are not necessarily homogeneous in formulation or processing. In addition to conventional unsweetened milk powders, some small- and medium-scale producers manufacture sweetened goat milk products through open-pan heating and crystallization, in which substantial amounts of sugar are incorporated before drying. Such formulation and processing characteristics should be considered when interpreting the nutritional composition and selecting an appropriate quality benchmark.

Although powdered goat's milk offers various advantages in terms of practicality and shelf life, its processing has the potential to affect the quality of the final product if not properly controlled [13]. Various production stages, from raw material quality and heating, drying, milling, and packaging, can cause changes in the physical, chemical, and microbiological characteristics of the product [14], [15]. Furthermore, powdered milk products are also potentially contaminated by pathogenic microorganisms, heavy metal contaminants, and prohibited chemicals if hygiene, sanitation, and production process control are not optimally implemented [16], [17]. These conditions not only can reduce product quality but also potentially affect food safety and consumer confidence in the resulting product. Therefore, quality control through the evaluation of chemical and microbiological parameters is a crucial part of the powdered milk industry's quality assurance system to ensure that marketed products meet safety, quality, and consumption requirements [18], [19].

To ensure product safety and consistent quality, powdered milk quality evaluation must adhere to established standards. In Indonesia, powdered milk quality requirements are regulated by the *Standar Nasional Indonesia* (SNI) 2970:2015, which covers various chemical parameters, metal contamination, microbiological contamination, and the presence of prohibited chemicals. These parameters serve as indicators in assessing whether powdered milk products meet food safety requirements and are suitable for public consumption [20], [21]. In addition to complying with regulations, implementing quality standards is also an important part of the industrial quality control system to ensure consistent product quality, increase consumer confidence, and strengthen product competitiveness in the market [22]. Evaluating the conformity of the chemical and microbiological characteristics of powdered milk products to applicable standards is a crucial step in supporting the implementation of a quality assurance system in the milk processing industry [23], [24].

Various studies on goat's milk have focused primarily on nutritional characteristics, bioactive compounds, product development, and processing technologies to improve product quality and stability [25], [26]. However, less attention has been given to the quality evaluation of small- and medium-scale sweetened powdered goat milk products manufactured using traditional or semi-traditional crystallization-based processes. In particular, there is limited information on how the chemical and microbiological characteristics of such products compare with existing national quality requirements and whether those requirements are directly applicable to the product category. Therefore, a study on the conformity of powdered goat milk products to national standards still has scientific and practical relevance to support the improvement of quality assurance systems in the goat milk processing industry [27], [28]. Therefore, evaluating the product against an established standard requires not only reporting compliance but also considering whether the product characteristics and the intended standard are appropriately aligned. This research does not focus on formulation development or processing technology, but rather on evaluating the quality of final products that have been commercially produced against applicable quality requirements.

Based on the description, this study aims to evaluate the chemical and microbiological quality characteristics of powdered *etawa* goat milk products produced by a powdered *etawa* goat milk factory in Yogyakarta and compare the test results with the quality requirements stipulated in SNI 2970:2015. The results of this study are expected to provide information on the level of conformity of product quality to applicable standards and become input for the industry in efforts to maintain and improve the quality control system of powdered goat milk products. In addition, this study provides an overview of the conformity of the quality of commercially produced powdered *etawa* goat milk

products to national standards, so that it can be a reference for the industry and stakeholders in supporting the implementation of quality assurance systems and food safety in powdered goat milk products.

2. Method

2.1. Study Design

This research used a descriptive observational design to evaluate the chemical and microbiological characteristics of a powdered *Etawa* goat milk product. One product sample from a single production batch was analyzed, and no independent sampling replication or duplicate/triplicate analytical measurements were performed. Therefore, the study provides a batch-specific quality snapshot rather than an estimate of production-wide or market-level product conformity. Laboratory results were analyzed descriptively by comparing the measured values with the applicable requirements of SNI 2970:2015. No inferential statistical analysis was performed because the study had no replication and therefore did not provide sufficient observations for estimating variability or testing statistical differences.

2.2. Production of *Etawa* Goat Milk Powder

Powdered *etawa* goat milk is produced at an *etawa* crossbred goat milk factory in Yogyakarta using an open-pan drying method. Fresh goat milk that meets quality requirements undergoes organoleptic inspection and specific gravity measurements before being used as a raw material. Next, the fresh goat milk is mixed with refined crystal sugar at a ratio of 1 L of milk to 400 g of sugar for each formulation.

The milk and sugar mixture is heated at around 99–100°C for approximately 30 minutes with continuous stirring, until a thick milk paste forms. After initial heating, the paste is cooled for 10–15 minutes by spreading it on a pan to lower the temperature. Approximately 150 g of dry powdered goat milk is added to the paste as a seed powder to accelerate the crystallization process and granule formation.

The mixture is then reheated over low heat for approximately 1–2 hours, stirring continuously, until dry milk granules form. The dried product is then ground using a flouring machine to achieve a more uniform particle size. The ground goat milk powder is then packaged according to product size using polypropylene or aluminum foil packaging, sealed using a sealer machine and stored in a dry storage room using the first in first out (FIFO) system before distribution.

2.3. Heavy Metal Analysis

Heavy metal analysis was conducted to evaluate the presence of metal contamination in powdered *etawa* crossbred goat milk products [29], [30]. The parameters analyzed included plumbum (Pb), cadmium (Cd), tin (Sn), mercury (Hg), and arsenic (As). The testing was conducted using the Inductively Coupled Plasma–Optical Emission Spectrometry (ICP-OES) method by an accredited testing laboratory in accordance with laboratory operational procedures. The test results were expressed in mg/kg.

2.4. Moisture Content Analysis

The moisture content of powdered goat milk products was analyzed using a gravimetric method [31]. The analysis was conducted to determine the water content in the product, a quality parameter that affects the stability and shelf life of powdered milk [32]. Test results were expressed as a percentage (%).

2.5. Protein Content Analysis

The protein content of powdered goat milk products was analyzed using the kjeldahl method [33]. The analysis was conducted to evaluate protein content, a key parameter in powdered milk quality. Test results were expressed as a percentage (%).

2.6. Fat Content Analysis

The fat content of powdered *etawa* goat milk products was analyzed using the soxhlet method [34]. The analysis was conducted to evaluate fat content as a key parameter in powdered milk quality. Test results were expressed as a percentage (%).

2.7. Chemical Contamination Analysis

Chemical contaminant analysis was conducted to detect the presence of melamine, alcohol, caffeine, and quinine in powdered *etawa* goat milk products. Testing was conducted by an accredited testing laboratory using LC-MS/MS methods for melamine [35], [36], GC for alcohol [37], HPLC for caffeine [38], and TLC for quinine.

2.8. Prohibited Chemical Analysis

A prohibited chemical analysis was conducted to detect the presence of formaldehyde, borax, methanyl yellow, and rhodamine B in powdered *etawa* goat milk products using a test kit by an accredited testing laboratory.

2.9. Microbiological Analysis

Microbiological analysis was conducted to evaluate the microbiological safety of powdered *etawa* goat milk products. Parameters analyzed included *Staphylococcus aureus* and *Salmonella spp.* using the spread plate method by an accredited testing laboratory.

3. Results and Discussion

3.1. Proximate Characteristic Evaluation

Proximate characteristics are one of the main indicators in determining the quality of powdered milk because they relate to product stability during storage, nutritional value, and consumer acceptance [9], [39]. The results of the proximate analysis of powdered *etawa* goat milk, presented in Table 1, indicate that the moisture and fat content meet the quality requirements stipulated in SNI 2970:2015, while the protein content remains below the minimum required limit.

Table 1. Proximate characteristics of *etawa* goat powder milk

Parameter	Results	SNI 2970:2015
Moisture content (%)	1.54	Maximum 5
Protein content (%)	16.87	Minimum 32
Fat content (%)	29.12	>26; <42

The product's moisture content of 1.54% indicates that the drying process was effective, resulting in a product with a low water content. A low moisture content is a crucial factor in maintaining product stability during storage because it inhibits the growth of microorganisms, slows chemical reactions, and reduces the risk of product damage due to high water activity [40]. Furthermore, a moisture content below the maximum SNI limit indicates that the drying process has produced powdered milk with good storage characteristics.

The fat content of 29.12% also meets the required range in SNI 2970:2015. Fat content is an important component that contributes to the flavor, texture, energy value, and physical characteristics of powdered milk [41]. These results indicate that the processing process applied was able to maintain the product's fat content, remaining within the required quality range.

Unlike other parameters, the protein content obtained, at 16.87%, was still lower than the minimum requirement of 32% according to SNI 2970:2015. This low protein content is likely influenced by several factors, such as the characteristics of the raw materials, product formulation, and processing. During the production process, the addition of relatively high amounts of refined sugar can increase the proportion of non-protein solids, resulting in a lower protein percentage in the product [42]. Furthermore, the relatively long heating process has the potential to cause protein denaturation

[43]. Although denaturation does not eliminate the total nitrogen content as measured by the Kjeldahl method, changes in protein structure during the heating process can affect the functional characteristics of the protein in the product [44]. The interpretation of the protein result requires particular caution. The analyzed product is not an unsweetened milk powder produced solely by concentrating and drying milk; it is a sweetened product manufactured using an open-pan crystallization process with a formulation of 1 L milk to 400 g refined sugar, followed by the incorporation of seed powder. Consequently, the addition of a substantial amount of sugar increases the proportion of non-protein solids in the final product and dilutes the relative percentage of milk-derived protein. The observed protein concentration of 16.87% therefore cannot be attributed solely to protein loss during heating. Moreover, Kjeldahl analysis determines total nitrogen rather than the structural integrity of proteins, meaning that protein denaturation itself would not adequately explain a reduction of total protein from the expected milk-derived proportion to the observed value.

More importantly, the apparent non-conformity should be interpreted in the context of product categorization. SNI 2970:2015 specifies a minimum protein requirement for milk powder, whereas the analyzed product contains a substantial amount of added sugar and is manufactured through crystallization rather than conventional spray drying. Thus, applying the 32% protein criterion directly may not fully reflect the intended composition or identity of this sweetened product. The present result should therefore be regarded as a discrepancy relative to the selected milk-powder benchmark rather than definitive evidence that the production process failed to produce a nutritionally acceptable product. Determining whether the product should be evaluated under SNI 2970:2015 or another applicable product specification requires clarification of its regulatory product category and formulation.

Overall, the proximate analysis results indicate that powdered *etawa* goat milk products meet most of the quality requirements based on SNI 2970:2015, particularly in terms of moisture and fat content. However, the protein content that did not meet the requirements indicates that further optimization of the formulation and production process is still needed to improve the nutritional quality of the product and ensure its compliance with national standards.

3.2. Chemical Safety Evaluation

The results of the chemical safety evaluation of powdered goat milk products are presented in Table 2. None of the analyzed heavy metals (Pb, Cd, Sn, Hg, and As) was detected. Melamine, formaldehyde, borax, methanyl yellow, and rhodamine B were also not detected or tested negative. Alcohol and caffeine were not detected, whereas quinine was reported as <6 mg/kg. These findings indicate that the analyzed batch did not show detectable contamination by the targeted chemical hazards at the detection capability of the respective analytical methods.

Table 2. Chemical component of *etawa* goat powder milk

Parameter	Results	SNI 2970:2015
Pb (mg/kg)	Not detected	Maximum 0.02
Cd (mg/kg)	Not detected	Maximum 0.2
Sn (mg/kg)	Not detected	Maximum 40/250
Hg (mg/kg)	Not detected	Maximum 0.03
As (mg/kg)	Not detected	Maximum 0.1
Melamine (mg/kg)	Not detected	Negative
Formalin (mg/kg)	Negative	Negative
Borax	Negative	Negative
Methanyl yellow (mg/kg)	Negative	Negative
Rhodamine B	Negative	Negative
Alcohol (mg/kg)	Not detected	Negative
Caffeine	Not detected	Negative
Quinine (mg/kg)	<6	-

All analyzed heavy metals, namely plumbum (Pb), cadmium (Cd), tin (Sn), mercury (Hg), and arsenic (As), were not detected in the powdered goat milk products. Heavy metals are contaminants that require attention because they can originate from the environment, animal feed, water, and

processing equipment. The accumulation of heavy metals in food can cause toxic effects if consumed over the long term [45]. The absence of detectable heavy metals provides evidence that the analyzed batch was not contaminated with Pb, Cd, Sn, Hg, or As at concentrations detectable by the analytical method. However, this result should not be interpreted as evidence that the raw materials or the overall production system were consistently free from heavy-metal contamination, because only one production batch was evaluated and method-specific LOD/LOQ values were not available. Potential sources of heavy-metal contamination in dairy products include feed, water, environmental exposure, and food-contact materials; therefore, monitoring across multiple batches would be required to assess consistency.

The negative results for melamine, formaldehyde, borax, methanyl yellow, and rhodamine B are likewise limited to the analyzed batch. These results indicate no detectable presence of the targeted prohibited substances in this sample but cannot establish their absence across all production batches. Similarly, the non-detection of alcohol and caffeine provides a batch-specific observation rather than evidence of systematic control over these compounds. Quinine was reported as <6 mg/kg; however, because no corresponding limit is specified in the SNI criterion presented in Table 2, this result should be interpreted descriptively rather than as a formal compliance assessment.

3.3. Microbiology Evaluation

The results of the microbiological evaluation of powdered *etawa* goat milk products are presented in Table 3. The parameters analyzed included *Salmonella* spp. and *Staphylococcus aureus* as indicators of the microbiological safety of powdered milk products. The test results showed that neither parameter was detected, thus meeting the microbiological requirements based on SNI 2970:2015.

Table 3. Microbiology evaluation of *etawa* goat powder milk

Parameter	Results	SNI 2970:2015
<i>Salmonella</i> (25 g)	Not detected	Maximum 1×10^2
<i>Staphylococcus aureus</i> (CFU/g)	Not detected	Negative/25 g

The presence of *Salmonella* spp. and *Staphylococcus aureus* in dairy products is an important indicator in food safety assessments because both microorganisms can cause foodborne illnesses [46]. *Salmonella* spp. contamination generally originates from raw materials, the production environment, or poor sanitation during processing, while *Staphylococcus aureus* is often associated with contamination from workers, equipment, or unhygienic product handling [47], [48]. The absence of these microorganisms indicates that the analyzed batch showed satisfactory microbiological safety at the time of testing. However, because only one production batch was examined, the findings cannot be used to establish consistent microbiological control across production batches. The observed results may reflect the combined effects of the heat treatment, low moisture content, hygiene practices, sanitation, and post-processing handling, but the present study was not designed to determine the contribution of each factor. Therefore, the microbiological findings should be interpreted as a batch-specific quality assessment rather than evidence of system-wide microbiological control.

Furthermore, the heating process during production also contributes to reducing the number of microorganisms in the final product. The product's low moisture content inhibits the growth of microorganisms during storage, thereby helping maintain product stability and safety [49], [50]. Therefore, the results of this study indicate that powdered *etawa* crossbred goat milk meets the microbiological safety requirements of SNI 2970:2015 and reflects the implementation of sound quality control throughout the production process.

3.4. Overall Quality Evaluation of Powdered *Etawa* Goat Milk

A comprehensive quality evaluation showed that most of the chemical and microbiological parameters of powdered *etawa* crossbred goat milk products met the quality requirements stipulated in SNI 2970:2015 (Table 4). All chemical safety parameters, including heavy metals, prohibited chemicals, and other chemical contaminants, showed results in accordance with the standards.

Furthermore, the microbiological parameters also met the requirements, as no *Salmonella spp.* or *Staphylococcus aureus* were detected.

Table 4. Quality evaluation of *etawa* goat powder milk

Parameter	Status
Proximate	Partially qualified
Chemical contamination	Qualified
Microbiology	Qualified

The main discrepancy was the protein content of 16.87%, which was substantially below the 32% minimum specified for milk powder in SNI 2970:2015. However, this finding should not be interpreted solely as a production failure. The product contains a substantial amount of added sugar (400 g per 1 L milk) and is manufactured through an open-pan crystallization process. The added sugar increases the proportion of non-protein solids and consequently lowers the protein percentage in the final product. Therefore, the observed protein value highlights an important question regarding the applicability of the milk-powder specification to this particular sweetened product category.

Accordingly, the present study supports the chemical and microbiological safety of the analyzed batch but does not provide sufficient evidence to establish overall conformity of the product category or consistency of the production process. A more definitive assessment would require clarification of the appropriate regulatory classification of the product, examination of the applicable product-specific standard, and evaluation of multiple production batches with analytical replication.

4. Conclusion

This study demonstrated that the chemical and microbiological quality of powdered *etawa* goat milk generally complied with the requirements of SNI 2970:2015. The moisture and fat contents met the specified quality standards, while all evaluated heavy metals, prohibited chemicals, and other chemical contaminants were not detected or remained within acceptable limits. Furthermore, the absence of *Salmonella spp.* and *Staphylococcus aureus* indicated that the product fulfilled the microbiological safety requirements. However, the protein content did not meet the minimum requirement specified in SNI 2970:2015, indicating that further optimization of product formulation and processing conditions is necessary. Overall, the findings suggest that the implemented quality control system has been effective in ensuring product safety, although improvements are still required to enhance nutritional quality and achieve full compliance with the national standard.

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