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Effects of Plant Coagulants Based *Calotropis procera* (Aiton) W.T. Aiton, *Balanites aegyptiaca* (L.) Del., and *Moringa oleifera* Lam on Fresh Cheese in Burkina Faso

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Abstract Milk and dairy products are essential nutritional resources in Africa, where the demand for animal proteins continues to rise despite limited accessibility to dairy products. The growing consumption of fresh cheese has increased pressure on rennet supplies, while evolving dietary habits, including vegetarian and ethical considerations, have stimulated researches for alternative solutions. In this context, the present study investigated locally available plant coagulants as sustainable options for cheesemaking. The objective was to assess the effectiveness of milk coagulation induced by plant coagulants compared with acetic acid. The working hypothesis was that these plant coagulants would provide higher yields than traditionally used agents. To test this hypothesis, varying doses of *Calotropis procera* (W.T. Aiton) stems (young and old), *Balanites aegyptiaca* (Lise Bessot) leaves, and *Moringa oleifera* (Lam) seeds were applied to cow's milk, with acetic acid serving as a reference. The parameters evaluated included coagulation time, fresh cheese yield, and sensory attributes (taste, aroma, texture, acidity, flavor, and color). Descriptive statistics and statistical tests were performed using XLSTAT software. Results revealed contrasting performances: young stems of *Calotropis procera* produced the highest yield (307 g/L) even at low doses, confirming their strong coagulating efficiency. Cheeses derived from *Moringa oleifera* seeds and acetic acid were the most appreciated in terms of sensory quality, whereas those obtained with *Balanites aegyptiaca* leaves showed organoleptic limitations due to the presence of saponins and flavonoids. These findings partially validate the initial hypothesis and highlight the relevance of plant coagulants for sustainable cheesemaking adapted to African local conditions, while contributing to global efforts to identify viable alternatives to animal rennet.

Keywords: *Milk, Plant coagulants, Cheese, Yield*

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1. Introduction

Food is a vital need for humans, yet regular access remains uncertain in many African countries. Ensuring adequate daily consumption is a major challenge, particularly with regard to the supply of animal proteins. Demographic growth, rapid urbanization, rising incomes, and changing dietary habits have generated strong demand for animal products, which local production struggles to meet [1,2]. Among the most accessible sources of protein, ruminant milk occupies a central place. Initially intended for the nourishment of young animals, milk has become widely integrated into human diets. Its richness in proteins, lipids, lactose, and micronutrients makes it a food of high nutritional and energetic value [3,4,5]. However, its high water content and microbial load render it highly perishable, requiring cold storage. In rural African areas, this constraint leads to considerable losses, forcing producers to rapidly transform milk into derivatives such as yogurt, curdled milk, or cheese [6].

Cheese, a dairy product of high nutritional and organoleptic value, is among the most consumed milk derivatives. Its production relies on a key step: coagulation, which involves the formation of curd through chemical and physical modification of caseins [7,8]. Traditionally, this process was carried out using rennet, an enzyme extracted from the abomasum of young ruminants [9]. However, rennet availability has declined due to constraints related to calf slaughter, the expansion of industrial cheesemaking, and religious or philosophical considerations [9,10]. Consequently, research has turned toward alternative coagulants, particularly of plant origin [10].

In Africa, several plants are traditionally used in local cheesemaking, including *Calotropis procera* (W.T. Aiton) [11]. This species is notably employed in the production of wagashi, a soft Peulh cheese obtained by hot coagulation of whole raw milk under the action of calotropaine [11,12,13,14,15]. Widely consumed in Benin and certain regions of Burkina Faso, wagashi has the advantage of not requiring refrigeration, making it well adapted to local socio-economic conditions [15].

These locally available plant coagulants represent promising alternatives to rennet. However, their effectiveness varies depending on the species, the plant parts used (leaves, stems, seeds), and processing conditions [14,15]. Hence, it is crucial to evaluate their coagulation capacity and their impact on the organoleptic properties of cheese. The research question addressed in this study concerns the ability of *Balanites aegyptiaca* (Lise Bessot), *Moringa oleifera* (Lam), and *Calotropis procera* to ensure effective coagulation of cow's milk and to produce cheeses with acceptable technological and sensory characteristics. The working hypothesis is that extracts from these plants possess sufficient coagulating activity to transform milk into cheese with satisfactory yields and organoleptic qualities. Accordingly, the study aims to determine the cheese yields obtained with each coagulant, to characterize the sensory properties of the products, and to assess the socio-economic relevance of their use in the African context.

2. Material and Methods

2.1. Milk and Coagulants

Fresh whole milk from several cows was the main raw material used for fresh cheese production. This milk was obtained from a semi-intensive farm with crossbred dairy cows. The main plant coagulants used in the study were stems of *Calotropis procera* (young and old stems), leaves of *Balanites aegyptiaca*, and seeds of *Moringa oleifera*, Citric acid (8%) was also used for comparison with the performance of the plant coagulants.

2.2. Evaluation of Physicochemical Parameters of Milk

2.2.1. pH Measurement

A pH meter was used to measure milk acidity. The electrode was cleaned and rinsed with distilled water before each measurement. The electrode was immersed in milk, and the pH value was displayed on the screen. The electrode was cleaned after each measurement.

2.2.2. Density Measurement

Milk density was determined using a lactodensimeter. The instrument was cleaned before and after each measurement. It was immersed in a test tube containing milk, and the value was read directly from the graduated stem of the device.

2.2.3. Temperature Measurement

A thermometer was used to determine milk temperature. The probe was inserted into milk contained in a test tube, and the value was displayed directly on the screen. The probe was cleaned before and after each measurement.

2.2.4. Determination of Dry Matter, Fat, and Protein Content

These parameters were measured using infrared analysis with the Farm Milk Analyzer (2001, Miris AB, Sweden). The infrared principle consists of passing electromagnetic waves with wavelengths between 0.78 and 1000 mm through the milk sample. A 10 ml sample at +40°C was injected into the device using a syringe. Two minutes after analysis, the results were displayed as percentages [16,17].

2.3. Preparation of Coagulants

Four types of coagulants were used for milk coagulation: fresh leaves of *Balanites aegyptiaca*, stems of *Calotropis procera*, seeds of *Moringa oleifera*, and 8% citric acid.

2.3.1. Fresh Leaves of *Balanites aegyptiaca*

The leaves were first harvested and cleaned. They were then pounded in a mortar. and the resulting paste was weighed according to the doses required for the experiment. This operation was repeated for each cheese-making trial. The paste was mixed with a small amount of milk and directly filtered into the milk under processing using a sieve.

2.3.2. Fresh Stems of *Calotropis procera*

Both young and old stems of *Calotropis procera* were sorted, washed, and pounded separately in a mortar. The resulting paste was weighed according to the experimental doses. The operation was repeated for each transformation. The paste was mixed with a small amount of milk and directly filtered into the milk under processing using a sieve.

2.3.3. Seeds of *Moringa oleifera*

The seeds of *Moringa oleifera* were purchased, weighed, and ground using an electric blender. The resulting powder was stored in small labelled plastic containers. During each cheese-making trial, the moringa seed powder was mixed with a small amount of fresh milk and filtered into the milk under processing.

2.3.4. 8% Citric Acid

A fixed volume (10 ml) of 8% citric acid was measured and directly added to the milk under processing.

2.4. Fresh Cheese Production

Fresh cheese production was conducted using a cold-start method, in which milk and coagulant were mixed directly, as traditionally practiced in certain regions of Benin. Upon collection, the milk was homogenized by stirring, then filtered through a sieve, and samples were taken for standardized measurements and analyses. For each treatment, one liter of milk was allocated to fresh cheese production with the corresponding coagulant dose.

The coagulant, previously diluted in a portion of milk and filtered, was added to the saucepan containing the remaining milk. The mixture was gently heated until curd formation occurred, after which the temperature was increased to cook the curd, with salt incorporated during the process. The final step involved whey drainage. At the end of cooking, the mixture was transferred into perforated molds to separate curd from whey. Each cheese was drained for one hour, then weighed and stored under refrigeration. Production time was recorded for all samples.

Table 1. Coagulation quantity per liter of milk

Type of Coagulant	Quantity (g)
Fresh Leaves of *Balanites aegyptiaca*	60
	80
	100
	120
Seeds of *Moringa oleifera*	30
	40
Young fresh Stems of *Calotropis procera*	40 60 80 100
Old fresh Stems of *Calotropis procera*	80 100
Citric Acid 8%	10ml

2.5. Evaluation of the Organoleptic Quality of Cheeses

To evaluate the organoleptic qualities of the cheeses, tasting sessions were organized with sixty consumers. All participants provided written informed consent before taking part in the sensory evaluation tests, in accordance with ethical research standards. Each participant completed a structured questionnaire covering the main sensory attributes, including color, appearance, flavor, texture, and taste. Beyond these evaluations, the cheeses were ranked according to predefined criteria, combining overall sensory scores with consumer preferences. This ranking system made it possible to identify the most appreciated cheeses by assigning a score to each one [15].

2.6. Cost Analysis of Fresh Cheeses

The cost analysis of the cheeses involved identifying and quantifying all expenses related to the production process, from the supply of raw materials (milk, coagulants, complementary ingredients) to operational charges (labor, energy, packaging, transport). The data were organized to calculate the production cost per kilogram of cheese.

2.7. Statistical Analysis

Microsoft Office Excel was used for data processing and graphical illustrations. Descriptive statistics. Pearson correlation matrices and p-values were determined using XLSTAT software. Differences between means were considered significant at a probability threshold of $p < 0.05$. The RuralInvest software (RIV20 for Windows (x64)). developed by FAO. was used to calculate the production cost of the cheeses.

3. Results and Discussion

3.1. Milk Quality

For fresh cheese production, it is essential that the milk used be of high physicochemical and microbiological quality. The composition of raw milk strongly influences the characteristics of the final dairy product. In particular, fat and protein contents affect coagulation rate, cheese yield [18,19] and organoleptic quality [19,20]. Proteins play a central role in cheesemaking technology due to their coagulating properties [17,21]. According to [16], milk from Peulh Zebu cows the most widespread breed in semi-improved farms in Burkina Faso contains 4.8% fat, 3.4% protein, and 4.8% lactose in morning milking. These values are comparable to those obtained in the present experiment (4.9% fat, 3.5% protein, 9.3% dry matter). During the study, the milk pH was measured at 6.07 (Table 2), which differs from the standard value of 6.6 considered optimal for enzymatic coagulation [18,19]. The decrease in pH observed may be attributed to the absence of cooling prior to milk delivery, which favoured bacterial activity and subsequent acidification. Nevertheless, this pre-processing acidification did not visibly affect the experiment, as the same batch of milk was used for all fresh cheese productions.

Table 2. Chemical and physical composition of milk

	pH	Density	CF	CP	DM
Raw milk	6.07 ± 0.24	1.032 ± 0.002	4.88 ± 0.68	3.48 ± 0.21	9.28 ± 0.91

pH: potential of hydrogen; CF: Crude fat; CP: Crude protein; DM: Dry matter.

3.2. Coagulation Efficiency

3.2.1. Coagulation Time

Fresh cheese production is influenced by several technological parameters that determine the quality of the final product. In this study, the effect of natural coagulants on cheese yield was evaluated under controlled conditions. The coagulant was added directly to cold milk at ambient temperature, without preheating to 40 °C as reported in some studies. This practice, common among producers in northern Benin, helps preserve protein integrity and prevent thermal denaturation, but slows down enzymatic activity and prolongs curd formation. Recent studies confirm that adding coagulants at low temperature modifies coagulation kinetics and may affect the final texture of cheese [18,20,22].

Coagulation time varied according to the quantity, origin, and nature of the coagulant. Lower doses resulted in longer coagulation times (Table 3), with significant differences observed at $p < 0.05$. Estimating coagulation time is crucial for identifying the most economically efficient coagulant. Gel formation accelerated with increasing coagulant concentration, highlighting the importance of dosage in coagulation speed [22,23].

The coagulation times obtained for *Calotropis procera* and acetic acid were consistent with values reported in the literature. For *Calotropis procera*, coagulation ranged from 10 to 25 minutes [14,22,24], while acetic acid induced coagulation within 5 to 12 minutes [25,26]. In contrast, coagulation times for *Balanites aegyptiaca* leaves and *Moringa oleifera* seeds were shorter than those reported by [22] and [27] (20-35 minutes for *Balanites aegyptiaca*) and by [28] and [22] (30-45 minutes for *Moringa oleifera*). These discrepancies may be explained by differences in the plant parts used. Acetic acid coagulates milk more rapidly due to its higher acidity [26].

Overall, *Calotropis procera* proved to be the most effective plant coagulant, with coagulation times approaching those of animal rennet, which typically ranges from 12 to 15 minutes at 30–32 °C [18].

3.2.2. Cheese Yield

Cheese yield varied according to the amount of coagulant used. Regardless of the type of coagulant, higher doses consistently produced greater yields. Young stems of *Calotropis procera* demonstrated remarkable coagulation efficiency, achieving high yields even at the lowest dose (40 g), with up to 307 g of cheese per liter of milk. This performance exceeded values reported by [24] (latex: 120–180 g), [22] (latex: 140–200 g), [14] (latex: 150–220 g), [15] (stem: 180 g), and [23] (purified enzymes: 120–200 g). These findings confirm the traditional use of *Calotropis procera* in Wagashi cheesemaking among several African communities [14]. The effectiveness of this plant is attributed to cysteine proteases (calotropain), which hydrolyze κ-casein, destabilize casein micelles, and promote curd formation [14,24]. In contrast, old stems yielded significantly less, likely due to reduced enzyme content associated with senescence and protease denaturation or oxidation [14].

Table 3. Coagulation time and cheese yield

Cheese	Coagulation time (min)	Weight of cheese (g)
120FB	8.50 ± 1.73^a	246.25 ± 20.45^b
100FB	10.25 ± 2.63^a	243.25 ± 18.14^b
80FB	16.50 ± 12.45^a	215.25 ± 50.71^b
60FB	25 ± 14.07^b	136 ± 74.60^c
30GM	29 ± 12.70^b	136.25 ± 79.55^c
40GM	11 ± 3.16^a	239.75 ± 19.15^a
40JT	12.75 ± 1.30^a	307.75 ± 26.65^a
60JT	14 ± 1.87^a	277.75 ± 34.21^a
80JT	13.50 ± 2.50^a	281 ± 23.91^a
100JT	13 ± 1.87^a	278.50 ± 20.76^a
80VT	20 ± 6.48^b	182.50 ± 116.76^b
100VT	13.67 ± 1.89^a	193.25 ± 119.78^b
10AC	11.75 ± .99^a	234.50 ± 16.78^b

For each column, values bearing different letters are significantly different at the p < 0.05 level. 120FB: 120 g of *Balanites aegyptiaca* leaves; 100FB: 100 g of *Balanites aegyptiaca* leaves; 80FB: 80 g of *Balanites aegyptiaca* leaves; 60FB: 60 g of *Balanites aegyptiaca* leaves; 30GM: 30 g of *Moringa oleifera* seeds; 40GM: 40 g of *Moringa oleifera* seeds; 40JT: Cheese obtained from 40 g of young stems of *Calotropis procera*; 60JT: Cheese obtained from 60 g of young stems of *Calotropis procera*; 80JT: Cheese obtained from 80 g of young stems of *Calotropis procera*; 100JT: Cheese obtained from 100 g of young stems of *Calotropis procera*; 80VT: Cheese obtained from 80 g of old stems of *Calotropis procera*; 100VT: Cheese obtained from 100 g of old stems of *Calotropis procera*; 10AC: Cheese obtained from 10 ml of citric acid.

For *Moringa oleifera* seeds, a significant difference ($p < 0.05$) was observed between the two doses tested (30 and 40 g). These seeds contain proteases capable of degrading κ-casein and inducing coagulation [29,30]. The 40 g dose produced the highest yield (239 g/L), while the 30 g dose yielded 136 g/L, consistent with values reported by [22] and [28]. The higher yield at 40 g exceeded those previously reported, confirming the dose-dependent effect of moringa seed proteases.

For *Balanites aegyptiaca* leaves, only the 60 g dose showed a significantly lower yield compared to higher doses ($p < 0.05$). Leaf extracts contain proteases in lower amounts than the fruit pulp, along with saponins and flavonoids that interfere with casein micelle stability, thereby reducing coagulation efficiency and cheese yield [31,32]. The yield obtained with 60 g was comparable to those reported by [27] (100–150 g/L) and [22] (110–160 g/L).

The control treatment with 10 ml of acetic acid produced lower yields than the higher doses of plant coagulants. However, the yields obtained in this study were higher than those reported by [25] and [26], likely due to the higher concentration of acetic acid applied.

3.3. Organoleptic Quality of Cheeses

The sensory evaluation of the cheeses focused on color, texture, taste, aroma, acidity, milky flavor, and sweet flavor. Assessments were conducted through a series of tastings of the different cheeses produced, with a panel composed of both genders, including a majority of male participants (60%). Sensory testing plays a fundamental role in validating processed products, as it ensures that technological characteristics (e.g., texture, yield, gel stability) align with consumer expectations. As emphasized in the literature, sensory evaluation is a key tool for linking the physicochemical properties of food to consumer perception, thereby facilitating successful market adoption [33].

3.3.1. Taste, Aroma, and Acidity

Most of the cheeses were rated as « acceptable », whereas the acetic acid cheese was considered « pleasant » in taste. In contrast, the cheese produced with 120 g of *Balanites aegyptiaca* leaves was judged « unpleasant », a result attributed to the presence of saponins and flavonoids that impart green coloration and bitter or herbaceous notes. These compounds limit sensory acceptability despite their coagulating activity [31,32,34]. Enhanced consumer preference for cheeses made with *Moringa oleifera* seeds has also been reported by [35] in Nigeria. Cheeses produced with *Calotropis procera* stems, rated « acceptable », did not exhibit bitterness compared to findings from other authors [14,36], likely due to lower concentrations of alkaloids and latex in stems relative to other plant parts. Regarding aroma, most cheeses were described as « pleasant », with only some samples from young stems of *Calotropis procera* rated as « acceptable », supporting their potential validation in terms of odor. Acidity was generally low, with cheeses described as « slightly acidic ». This can be explained by the fact that plant enzymes induce coagulation through κ-casein hydrolysis without producing large amounts of organic acids. Unlike lactic cultures, they do not accumulate lactic acid, which accounts for the lower acidity observed [36,37,38].

Table 4. Sensory perception of taste, aroma, and acidity

Cheeses	Taste	Aroma	Acidity
10AC	Pleasant	Pleasant	Low-acid
30GM	Pleasant	Pleasant	Low-acid
100VT	Acceptable	Pleasant	Low-acid
40GM	Acceptable	Pleasant	Low-acid
80VT	Acceptable	Pleasant	Not-acid
80JT	Acceptable	Acceptable	Low-acid
60FB	Acceptable	Pleasant	Low-acid
80FB	Acceptable	Pleasant	Not-acid
100FB	Acceptable	Pleasant	Not-acid
100JT	Acceptable	Acceptable	Not-acid
60JT	Acceptable	Acceptable	Low-acid
40JT	Acceptable	Acceptable	Low-acid
120FB	Unpleasant	Pleasant	Low-acid

120FB: 120 g of *Balanites aegyptiaca* leaves; 100FB: 100 g of *Balanites aegyptiaca* leaves; 80FB: 80 g of *Balanites aegyptiaca* leaves; 60FB: 60 g of *Balanites aegyptiaca* leaves; 30GM: 30 g of *Moringa oleifera* seeds; 40GM: 40 g of *Moringa oleifera* seeds; 40JT: Cheese obtained from 40 g of young stems of *Calotropis procera*; 60JT: Cheese obtained from 60 g of young stems of *Calotropis procera*; 80JT: Cheese obtained from 80 g of young stems of *Calotropis procera*; 100JT: Cheese obtained from 100 g of young stems of *Calotropis procera*; 80VT: Cheese obtained from 80 g of old stems of *Calotropis procera*; 100VT: Cheese obtained from 100 g of old stems of *Calotropis procera*; 10AC: Cheese obtained from 10 ml of citric acid.

3.3.2. Color, Texture, and Flavors

The coloration of the cheeses was strongly influenced by the nature of the coagulant. More pigmented coagulants imparted their hues to the cheeses. Thus, *Moringa oleifera* seeds, *Calotropis procera* stems, and acetic acid produced cheeses with « white » or « off-white » tones, likely due to the absence or low concentration of natural pigments in these coagulants [39]. In contrast, *Balanites aegyptiaca* leaves conferred « green » or « light green » hues, with intensity increasing proportionally to the dosage. These variations can be explained by the presence of phenolic compounds, natural pigments, and enzymes in the plant extracts used as coagulants [7].

The texture of the cheeses was generally soft, except for the sample produced with 30 g of *Moringa oleifera* seeds. At low doses, the coagulating activity of *Moringa oleifera* seeds is insufficient to hydrolyze κ-casein effectively, leading to partial coagulation and the formation of a crumbly, weakly structured gel. The coagulating efficiency of *Moringa oleifera* seeds is dose-dependent : low concentrations yield fragile gels, whereas higher doses improve texture [29].

All cheeses retained a perceptible milky flavor, attributable to residual lactose and volatile compounds characteristic of milk. Since plant coagulants do not induce lactic fermentation, unlike starter cultures, the aromatic profile remains close to that of fresh milk [36]. Furthermore, all cheeses exhibited a sweet taste, except the one produced with 30 g of *Moringa oleifera* seeds, which was only slightly sweet. This difference may be explained by incomplete coagulation at low doses, resulting in greaterchj loss, of soluble solids (including lactose) in the whey and reduced sweetness perception [35].

Table 5. Sensory perception of color, texture, and flavors

Cheeses	Color	Texture	Milky flavor	Sweet flavor
10AC	White	Soft	Perceptible	Sweet
30GM	Off-white	Crumbly	Perceptible	Low-Sweet
100VT	Off-white	Soft	Perceptible	Sweet
40GM	White	Soft	Perceptible	Sweet
80VT	Off-white	Soft	Perceptible	Sweet
80JT	Off-white	Soft	Perceptible	Sweet
60FB	Light green	Soft	Perceptible	Sweet
80FB	Light green	Soft	Perceptible	Sweet
100FB	Green	Soft	Perceptible	Sweet
100JT	Off-white	Soft	Perceptible	Sweet
60JT	Off-white	Soft	Perceptible	Sweet
40JT	White	Soft	Perceptible	Sweet
120FB	Green	Soft	Perceptible	Sweet

120FB: 120 g of *Balanites aegyptiaca* leaves; 100FB: 100 g of *Balanites aegyptiaca* leaves; 80FB: 80 g of *Balanites aegyptiaca* leaves; 60FB: 60 g of *Balanites aegyptiaca* leaves; 30GM: 30 g of *Moringa oleifera* seeds; 40GM: 40 g of *Moringa oleifera* seeds; 40JT: Cheese obtained from 40 g of young stems of *Calotropis procera*; 60JT: Cheese obtained from 60 g of young stems of *Calotropis procera*; 80JT: Cheese obtained from 80 g of young stems of *Calotropis procera*; 100JT: Cheese obtained from 100 g of young stems of *Calotropis procera*; 80VT: Cheese obtained from 80 g of old stems of *Calotropis procera*; 100VT: Cheese obtained from 100 g of old stems of *Calotropis procera*; 10AC: Cheese obtained from 10 ml of citric acid.

3.3.3. Ranking of Cheeses According to Tasters' Preferences

Table 6. Rank of Cheeses

Cheeses	Rank
10AC	1
30GM	2
100VT	3
40GM	4
80VT	5
80JT	6
60FB	7
80FB	7
100FB	9
100JT	10
60JT	11
40JT	12
120FB	13

120FB: 120 g of *Balanites aegyptiaca* leaves; 100FB: 100 g of *Balanites aegyptiaca* leaves; 80FB: 80 g of *Balanites aegyptiaca* leaves; 60FB: 60 g of *Balanites aegyptiaca* leaves; 30GM: 30 g of *Moringa oleifera* seeds; 40GM: 40 g of *Moringa oleifera* seeds; 40JT: Cheese obtained from 40 g of young stems of *Calotropis procera*; 60JT: Cheese obtained from 60 g of young stems of *Calotropis procera*; 80JT: Cheese obtained from 80 g of young stems of *Calotropis procera*; 100JT: Cheese obtained from 100 g of young stems of *Calotropis procera*; 80VT: Cheese obtained from 80 g of old stems of *Calotropis procera*; 100VT: Cheese obtained from 100 g of old stems of *Calotropis procera*; 10AC: Cheese obtained from 10 ml of citric acid.

The preferences of the tasters are recorded in Table 6. In terms of ranking, the cheeses produced with citric acid, *Moringa oleifera* seeds, and old stems of *Calotropis procera* were judged the most pleasant by the tasters. A similar result to that obtained with acetic acid was reported by [38] using citric acid. Indeed, controlled acidification produces more homogeneous and sensorially pleasant gels [38]. According to [29] and [35], tasters considered cheeses made with *Moringa oleifera* pleasant because they combine the milk flavor with a natural sweetness. Cheeses made with *Balanites aegyptiaca* leaves were rated the lowest. This situation may be due to the unpleasant taste conferred by *Balanites aegyptiaca* leaves. [32] and [34,37] demonstrated that extracts from *Balanites aegyptiaca* leaves present organoleptic limitations despite their coagulating activity.

3.3.4. Ranking of Cheeses According to Tasters' Preferences

The cost price per kilogram of cheese varied significantly with yield. Higher cheese output per liter of milk resulted in a lower unit cost (Table 7). The calculation included the costs of milk, coagulants, and energy, while labor and depreciation were excluded. Cheeses made with *Moringa oleifera* seeds were the most expensive (3905-5392 FCFA/kg), primarily due to the high market price of the seeds. Reducing this cost would require producers to cultivate their own *Moringa oleifera* seeds. In contrast, cheeses obtained from young stems of *Calotropis procera* were the most competitive (1732–1919 FCFA/kg). The difference between young and old stems is explained by yield variation. This observation aligns with [40], who demonstrated the impact of cheese yield on cost price.

Table 7. Cheeses cost price

Cheeses	Production cost (FCFA/kg)	Rank
10AC	2322	1
30GM	5392	2
100VT	2807	3
40GM	3905	4
80VT	2963	5
80JT	1905	6
60FB	3922	7
80FB	2481	7
100FB	2195	9
100JT	1919	10
60JT	1919	11
40JT	1732	12
120FB	2169	13

120FB: 120 g of *Balanites aegyptiaca* leaves; 100FB: 100 g of *Balanites aegyptiaca* leaves; 80FB: 80 g of *Balanites aegyptiaca* leaves; 60FB: 60 g of *Balanites aegyptiaca* leaves; 30GM: 30 g of *Moringa oleifera* seeds; 40GM: 40 g of *Moringa oleifera* seeds; 40JT: Cheese obtained from 40 g of young stems of *Calotropis procera*; 60JT: Cheese obtained from 60 g of young stems of *Calotropis procera*; 80JT: Cheese obtained from 80 g of young stems of *Calotropis procera*; 100JT: Cheese obtained from 100 g of young stems of *Calotropis procera*; 80VT: Cheese obtained from 80 g of old stems of *Calotropis procera*; 100VT: Cheese obtained from 100 g of old stems of *Calotropis procera*; 10AC: Cheese obtained from 10 ml of citric acid.

4. Conclusion

The plant coagulants studied demonstrate significant potential for milk valorization. Results indicate that locally available coagulants can serve as viable alternatives to animal rennet in the African context. Young stems of *Calotropis procera* stand out for their high yield and competitive cost, while *Moringa oleifera* seeds and citric acid provide superior sensory acceptability. Although effective, *Balanites aegyptiaca* leaves require adjustments to improve organoleptic quality. Optimizing doses and refining processing methods (e.g., enzymatic purification, thermal treatment) are therefore essential to enhance sensory performance. Integrating these coagulants into local fresh cheese production could strengthen sustainability, reduce milk losses, and improve access to affordable animal protein.

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Author Contributions

The conception, data collection, analysis, and writing of the study were carried out by Mariétou SISSAO; Irène Rayinwendé SAWADOGO and Seydou TRAORE contributed to the writing of the study; and Vinsoun MILLOGO contributed to the writing and supervision of the study. All authors have read and approved the final version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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