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Research on the Process of Processing Yogurt from Goat Milk Supplemented *Cordyceps Militaris*

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Abstract

Goat milk is known to be a rich source of nutrients. This study aims to determine the optimal parameters for the production of yogurt from goat milk supplemented with *Cordyceps militaris*. The goal is to create a new yogurt product that is beneficial to health, contributing to product diversification and increasing economic value. The study focuses on investigating the ratio of milk powder and the

amount of *Cordyceps militaris* added to the quality of the product. The results showed that using 14% milk powder and 0.1% *cordyceps sinensis* gives products with high quality and sensory value. The study also takes advantage of locally available raw materials to develop diversified and sustainable agricultural products.

Keywords: Processing Yogurt, *Cordyceps Militaris*, Vietnam

1. Introduction

Milk is one of the most nutritious foods, containing essential groups of substances such as protein, lipids, carbohydrates, minerals and vitamins. In particular, goat milk is increasingly gaining attention not only because of its nutritional value but also because of its biological properties that are beneficial to human health. In recent years, the trend of diversifying milk sources and developing products from goat milk is considered inevitable to meet the needs of consumers for natural, easily digestible and health-friendly foods [1]. Goat milk contains many essential amino acids that the human body cannot synthesize itself such as tryptophan, lysine, valine, isoleucine, cystine, tyrosine... Goat milk contains very little or no alpha-s1-casein (found in cow's milk and is the main cause of milk allergy) [2]. The amino acid composition of goat milk is rich, including many essential amino acids that the human body cannot synthesize itself, such as tryptophan, lysine, valine, isoleucine, cystine, and tyrosine [3]. The fat globules are small (2.5–3 µm), containing many short- and medium-chain fatty acids (MCT), which are easily broken down by intestinal lipase, so that the fat in goat milk is absorbed and metabolized faster than cow's milk. In addition, goat milk is also rich in monounsaturated and polyunsaturated fatty acids, vitamins A, D, B6, B12, and minerals such as Ca, P, Mg, Fe, Cu, and Zn — which play an important role in energy metabolism and immune enhancement [2]. The natural oligosaccharide content in goat milk, similar to that in breast milk, also acts as a prebiotic, supporting intestinal microflora and reducing the risk of constipation [4]. Goat milk also contains whey protein (WP) at 3-12 g/kg. Whey protein includes β-lactoglobulin (34%-47% of total WP), α-lactalbumin (17%-50% of total WP) and serum albumin (5%-22% of total WP). The nutritional value and characteristic flavor of goat milk have helped goat milk products become a profitable alternative in the future. Fermented goat milk beverages have both high sensory value and can be considered a good substitute for cow milk products for people with poor digestion [5]. Yogurt products are of interest because they have both high sensory value and contain beneficial lactic acid bacteria (*Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus*), which help balance the intestinal microflora, support digestion and improve health [6]. Many studies have shown that adding natural ingredients rich in bioactive substances, such as fruits or medicinal herbs, to the goat milk base helps to enhance the sensory value and biological function of yogurt [7].

Among potential natural ingredients, *Cordyceps militaris* has been noted in many research works to contain bioactive substances valuable compounds such as adenosine, cordycepin, polysaccharides, proteins, amino acids, vitamins and essential trace elements [8]. These compounds have antioxidant effects, enhance immunity, support energy metabolism, lower blood

sugar and protect cells. Due to that *Cordyceps* is increasingly widely used in functional foods and pharmaceuticals in many Asian countries such as China, Japan and Korea. Therefore, this study aims to create yogurt products with high sensory quality and biological value, both taking advantage of the available domestic goat milk source, increasing economic value for goat farmers and contributing to expanding the research direction of functional foods from goat milk rich in biological active substances.

2. Materials and Methods

2.1 Experimental materials and conditions

The experiment was conducted at the laboratory of Cuu Long University and the laboratory of Tien Giang University. Pure fresh goat milk was purchased from Dong Nghi Cooperative, Tien Giang province. Powdered milk made from goat milk was purchased from Caprilac Company - Australia. *Cordyceps* was purchased from Thien An *Cordyceps* Company Limited. The yeast used was Yogourmet yeast from Canada and Gelatin Gerlita (leaf form) from Italy.

2.2 Production procedure

Requirements for goat milk: Fresh milk is milked in the morning, without blood or dust, or other impurities, ensuring the milk is clean and milked from a goat that is not sick.

Homogenization: After mixing milk powder, fresh milk, the milk liquid is homogenized, carried out for about 2 minutes. Homogenization aims to reduce the size of the components, increase the level of milk dispersion, redistribute between fats and plasma. The result makes the raw material homogenized, smooth and durable.

Pasteurization: After homogenization, the milk liquid is pasteurized at 85-90°C for 15 minutes, the purpose is to destroy microorganisms that are harmful to the product and inactivate enzymes, thereby creating conditions for bacteria to function well, improving the quality of the product.

Cooling: The milk liquid is cooled to a temperature of about 43°C to facilitate the activity of lactic acid bacteria.

Mixing: The milk solution after adding the microbial preparation is stirred. Then, continue to add the ground *cordyceps* and sieve into the mixed milk solution.

Jar filling: The jar is washed, dried and the milk solution is poured in, covered to prepare for the fermentation stage.

Fermentation: The milk solution is fermented in an incubator at 43°C to facilitate the growth of bacteria during the experimental period. After coagulation, the product is refrigerated to complete the quality, the cooling temperature is from 4-5°C.

Preservation: Lower the temperature of the yogurt to 4-5°C and preserve.

2.3 Experimental design

2.3.1 Analysis of raw material composition of goat milk

The purchased milk is filtered to remove impurities and evaluate the chemical composition of the raw material, including physical and chemical analysis, determination of pH and brix with a pH meter and a photometer, determination of the acidity of fresh milk, and determination of fat, protein in fresh milk.

2.3.2 Experiment 1. Effect of the ratio of mixed milk powder on product quality

Fresh goat milk after purchase is filtered with cloth to remove impurities. Milk powder is mixed with water at ratios of 0%, 10%, 12%, 14% and 16% according to the experimental layout. The milk solution obtained is homogenized for 2 minutes to homogenize the components. Then, the milk solution is pasteurized at 85 - 90°C for 15 minutes. After pasteurization, the milk is cooled to 43°C, then the microbial preparation and ground *cordyceps* are added, mixed, and poured into the jar. The jar is placed in an incubator at 43°C for fermentation for 10 hours. After coagulation, the product is cooled at 4-5°C for 1 day. After the product is allowed to stabilize its structure, the monitoring parameters are evaluated. The products were measured for pH, viscosity, total solids, and texture using a pH meter, viscometer, refractometer, and texture meter, respectively.

2.3.3 Experiment 2. Effect of the ratio of mixed *cordyceps* on product quality

Fresh goat milk after purchase is filtered with cloth to remove impurities. Powdered milk is mixed with fresh goat milk at the ratios selected in experiment 1. The milk liquid obtained is homogenized for 2 minutes to reduce the size of the components. Then, the milk liquid is pasteurized at 85-90°C for 15 minutes. After pasteurization, the milk mixture is cooled to 43°C. The starter culture is then added at a ratio of 0.125%, followed by the addition of *Cordyceps* powder at 0.05–0.2% according to the experimental design. The mixture is then filled into jars for fermentation. The jar is placed in an incubator at 43°C for fermentation for 10 hours. After coagulation, the product is cooled at 4-5°C for 1 day. After the product is allowed to stabilize its structure, the monitoring parameters are evaluated. Products are rated on a 5-point scale, with 0 being disliked and 5 being liked the most.

2.4 Data collection and processing

The experiments were arranged completely randomly. The data are presented in statistical form and processed using Statgraphics Centurion XV.I.

3. Results and Discussion

3.1 Raw material quality assessment

Raw materials are an important factor determining product quality. Depending on the goat breed and feeding regime, the chemical composition can vary. Therefore, it is necessary to analyze the chemical composition of raw materials to determine the nutritional value of raw materials to find a reasonable processing process. The results of the basic chemical composition assessment of fresh goat milk raw materials in 100 mL are shown in Table 1.

Table 1: Basic chemical composition of fresh goat milk in 100 mL

S. No	Parameter	Unit	Value
1	Lipid	%	4
2	Protein	%	3.5
3	Brix	%	13
4	pH		6.8
5	Lactic acid	%	0.14

Cordyceps militaris is a precious medicinal herb. The results of the evaluation of the composition of *Cordyceps militaris* are shown in Table 2. The analysis results of *Cordyceps militaris* samples showed that the cordycepin and adenosine contents reached 397.12 mg/100g and 254.86 mg/100g, respectively, which are biological active substances with antioxidant properties, enhancing immunity and improving energy metabolism [8, 9]. The incorporation of *Cordyceps militaris* extract into goat milk base not only helps to supplement natural functional compounds but also increases the biological and sensory value of yogurt products, aiming to develop functional yogurt products that are beneficial to consumers' health.

Table 2: Cordycepin and adenosine content in *cordyceps* samples (mg/100g)

S. No	Parameter	Unit	Value
1	Cordycepin	mg/100g	397.12
2	Adenosine	mg/100g	254.86

3.2 The effect of milk powder ratio on the structure and sensory value of the product

Adding milk powder to the base milk before yogurt fermentation is a common technological solution to increase the dry matter and protein content, thereby improving the gel structure, increasing the viscosity, hardness and water retention capacity of the yogurt product [10, 11]. In addition, increasing the protein content also helps reduce whey separation and improve the product's sensory - key criteria for quality and consumer acceptability (Arab *et al.* 2022). In this study, by varying the milk powder ratio of 0%, 10%, 12%, 14% and 16 % compared to the amount of goat milk used to determine the appropriate supplementation level to achieve a balance between structural properties and sensory quality.

Table 3: Results of the influence of the ratio of added milk powder on the physical and chemical parameters of yogurt products

Concentration of milk powder	TSS before fermentation (%)	TSS after fermentation (%)	pH	Viscosity (mPa.s)	Hardness (g _{force})
0%	14.07 ^a	12.27 ^a	6.24 ^d	1977 ^a	8.53 ^a
10%	21.27 ^b	13.87 ^b	5.25 ^c	2239 ^b	20.0 ^b
12%	23.17 ^c	14.17 ^c	4.91 ^b	2562 ^c	25.27 ^c
14%	25.17 ^d	16.13 ^d	4.66 ^a	2793 ^d	27.83 ^c
16%	26.93 ^e	18.17 ^c	5.25 ^c	2852 ^c	30.93 ^d
F	**	**	**	**	**
CV (%)	8.24	9.01	8.73	8.34	9.80

Different superscripts (like letters) within a column indicate a statistically significant difference between the values in that column ($p < 0.05$)

The results presented in Table 3 show that the total solids value before fermentation increased significantly from 14.07% (0% sample) to 26.93% (16% sample), reflecting a significant increase in soluble solids content when adding milk powder. This result is completely consistent with the theory, because milk powder provides additional protein, lactose and minerals, contributing to the increase in total soluble solids of the milk solution [12]. After fermentation, the total solids value tended to decrease slightly because lactic acid bacteria used lactose as a substrate to produce lactic acid, however, this decrease gradually decreased in samples with high milk powder content (from 14.07% to 12.27% and from 26.93% to 18.17%). This phenomenon

shows that samples rich in solids have higher viscosity, which limits substrate diffusion, leading to lower loss of available sugar. Similar results were also observed by [13] when studying the effect of skimmed milk powder on the properties of yogurt, in which samples with high solids content showed lower lactose consumption and better structural stability. The pH value of yogurt gradually decreased with increasing milk powder addition (from 6.24 to 4.66), indicating stronger fermentation activity in samples with high protein and lactose content. The addition of milk powder increased the lactose substrate for lactic acid bacteria and provided additional casein protein, which helped to form a tight, more stable gel network during acidification. Protein also acts as a biological buffer, maintaining pH stability and contributing to increased gel strength [11, 12]. However, at 16% milk powder, the pH increased slightly to 5.25, due to the strong buffering effect of protein, which slowed down the final acidification process. This phenomenon is consistent with the observations of [14] and [15] that high-protein yogurt has a higher final pH and a slower pH decrease due to increased buffering capacity and high viscosity that limits lactic acid diffusion.

The viscosity of the product increased significantly from 1977 mPa.s (0%) to 2852 mPa.s (16%), suggesting that milk powder plays an important role in increasing gel density and water holding capacity. As the milk powder content increased, the casein-whey protein network became denser, limiting whey separation and improving the retention of the liquid phase. This phenomenon is consistent with the gel formation mechanism in yogurt described by [11], according to which the addition of 3–5% milk protein increased the storage modulus (G') and improved gel structure. Observation of Figure 4.1 also shows a clear change: the 0% and 10% samples have weak gels, easily separating whey; the 12–14% samples have a dense, homogeneous structure; while the 16% sample appears to have a thick and uneven gel phenomenon, reflecting an excessive increase in viscosity and hardness of the product. The hardness of the product increases significantly from 8.53 g force (0%) to 30.93 g force (16%), indicating the ability to form a stronger and more elastic gel with increasing milk powder content. The casein protein in milk powder contributes to the formation of a dense three-dimensional network, tightly linked with water and fat, making the product structure more stable and sustainable. However, at 16% milk powder, the gel tends to be solid and dry, reducing the smoothness and sensory acceptability of the product. The optimum limit was determined to be around 12–14 %, when the product reached a balance between thickness, smoothness and creamy feel. This result is consistent with the finding of [16] that when the gel becomes too hard, the creaminess and sensory preference decrease significantly. Similarly, [10] and [14] also confirmed that increasing the protein or solid content in yogurt increases the hardness and viscosity, but exceeding the optimum level will negatively affect the structure and sensory of the product.

Sensory scores for color, odor, taste and texture all increased with the proportion of milk powder and reached the highest value at 14 % (color = 4.26; taste = 4.06; texture = 4.06; flavor = 4.47). In the 0 % sample, the lowest sensory score was due to weak gel, easy separation of whey and poor surface uniformity; while the 12–14% samples showed a

more harmonious gloss, texture and milky taste, clearly reflecting the improvement in texture and feel with the increase in dry matter. The increase in dry matter from milk powder helped to reduce the harsh sour taste. However, at 16% milk powder, the sensory score decreased slightly (although still higher than the 0%) sample because the product became too thick and less smooth, leading to a decrease in the sensory value of the product.

Observation of Figure 1 clearly demonstrates the trend of low milk powder content samples (0–10%) showing whey separation and a liquid texture, while the 12–14% samples had a homogeneous gel, shiny surface and moderate viscosity. At 16%, the gel was thicker, the surface was drier and less shiny, corresponding to the decrease in sensory score. This result is consistent with the finding of [12] that increasing total solids improves the texture and sensory of yogurt, but exceeding the optimum level can result in a less smooth feel. [13] also noted a similar phenomenon when adding high levels of milk powder, increasing the thickness and reducing the smooth texture of the product.

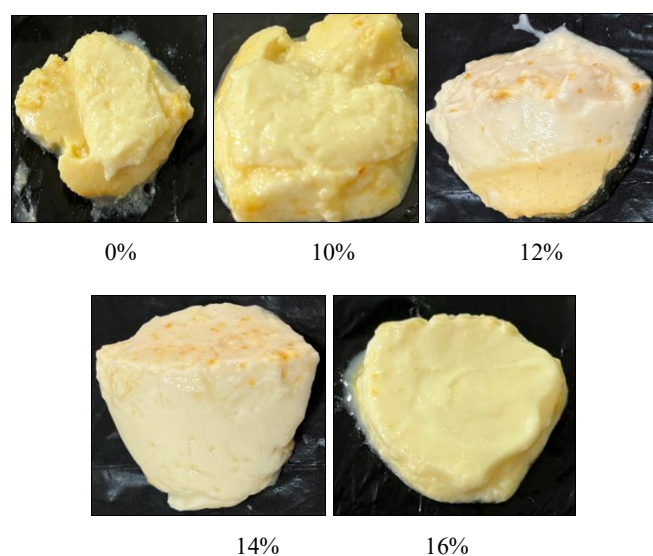


Fig 4.1: Effect of the ratio of added milk powder on yogurt products

The research results showed that the proportion of added milk powder has a clear effect on the physicochemical and sensory properties of yogurt. When the milk powder content increases, the Brix value and viscosity increase, the pH decreases appropriately, and the hardness and gel structure are improved, giving the product good water retention and a smoother surface. However, at too high a level (16%), the gel becomes too thick and dry, reducing the sensory score. Therefore, the proportion of added milk powder at 14% is determined to be the appropriate level, helping to balance the structural, viscosity and sensory values, ensuring the stability of the yogurt product increases.

3.3 Effect of the ratio of added *Cordyceps* on the structure and sensory value of the product

Cordyceps militaris is a rich source of bioactive compounds, the most important of which are cordycepin (3'-deoxyadenosine), adenosine, and polysaccharides. These compounds have been shown to have antioxidant, immunomodulatory, and anti-inflammatory potential activities, and are therefore recommended for use as a functional food ingredient [17]. The addition of *Cordyceps* to

yogurt not only enhances its nutritional value and biological function, but can also affect the fermentation process and gel structure due to the interaction between the bioactive compounds with milk proteins and lactic acid bacteria. Therefore, this experiment was conducted to evaluate the effects of different levels of *Cordyceps* supplementation (0.05–0.2%) on the physicochemical and sensory parameters of yogurt products, thereby determining the optimal supplementation ratio for a product rich in functional value and stable sensory. The results of the influence of the ratio of added *Cordyceps* on the physicochemical parameters of yogurt products are shown in Table 4.

Table 4: Results of the effect of the ratio of added *Cordyceps* on the physicochemical parameters of yogurt products

Sample	Ratio of added <i>Cordyceps</i> (%)	pH	Acid content (%)	Water separation (%)	Sensory value of color	Sensory value of structure
B1	0.05	4.73 ^b	0.88 ^a	12.10 ^b	4.33 ^a	4.63 ^{bc}
B2	0.10	4.73 ^b	0.88 ^a	12.00 ^b	4.44 ^b	4.67 ^c
B3	0.15	4.56 ^a	1.00 ^c	12.25 ^b	4.41 ^{ab}	4.46 ^{ab}
B4	0.20	4.69 ^{ab}	0.95 ^b	12.80 ^a	4.43 ^b	4.36 ^a
F		*	*	*	*	*
CV (%)		9.63	8.40	9.13	11.24	12.26

The results presented in Table 4 show that the addition of *Cordyceps militaris* at different ratios significantly affected the pH value, acidity, water separation ratio and sensory properties of yogurt products. According to [17], *C. militaris* is rich in functional active ingredients such as cordycepin, adenosine, D-mannitol and polysaccharide, which have the ability to fight oxidation and regulate the balance of beneficial microorganisms in fermented products. Although there have not been many direct studies on the effects of these compounds on lactic acid bacteria in yogurt, recent works, especially the study of [18] on freeze-dried yogurt kefir products supplemented with *C. militaris*, showed that the biological compounds of the mushroom do not inhibit the lactic acid bacteria system but also contribute to stabilizing the gel structure and sensory properties of the product. The results also suggest that the fungal organic compounds may influence the fermentation environment through buffering mechanisms and antioxidant activity, slightly reducing the acidification rate at high concentrations.

The pH values varied slightly from 4.56 to 4.73, while the acidity increased slightly from 0.88% to 1.00%, reflecting the change in acidification level when adding raw materials containing more biological compounds. At the addition level of 0.05–0.1%, the fermentation process was stable, maintaining the optimal pH for casein coagulation and stable gel formation; conversely, when the ratio increased to 0.2%, the buffering capacity of the fungal active ingredients could slow down the decrease in pH, causing the final acidification level to not change significantly.

The water separation ratio of the product varied between 12.00–12.8%. At low supplementation levels (0.05–0.1%), the gel structure was relatively stable with the lowest water separation (B2 – 12.00%), indicating that *Cordyceps sinensis* powder could interact slightly with the milk protein network, contributing to increased water retention and gel stability. This phenomenon is thought to be due to the ability of polysaccharides and proteins in the mushroom material to

hydrogen bond with casein, which helps to limit gel network shrinkage during the post-fermentation stage. However, when the supplementation level increased to 0.15–0.2%, the water separation increased again. [19] demonstrated that milk gel formation is strongly influenced by the homogeneity of the protein network, and any uneven dispersion increases the tendency for whey separation. Observations in Figure 2 show that samples containing 0.05–0.1% *Cordyceps* have a smooth, uniform surface, while samples containing higher concentrations show dark orange particles, unevenly distributed, clearly showing poor dispersion and slight whey separation — this was also noted by [18] when adding *Cordyceps militaris* to yogurt kefir products, suggesting that high concentrations of the fungus can reduce the cohesion and stability of the milk gel structure.

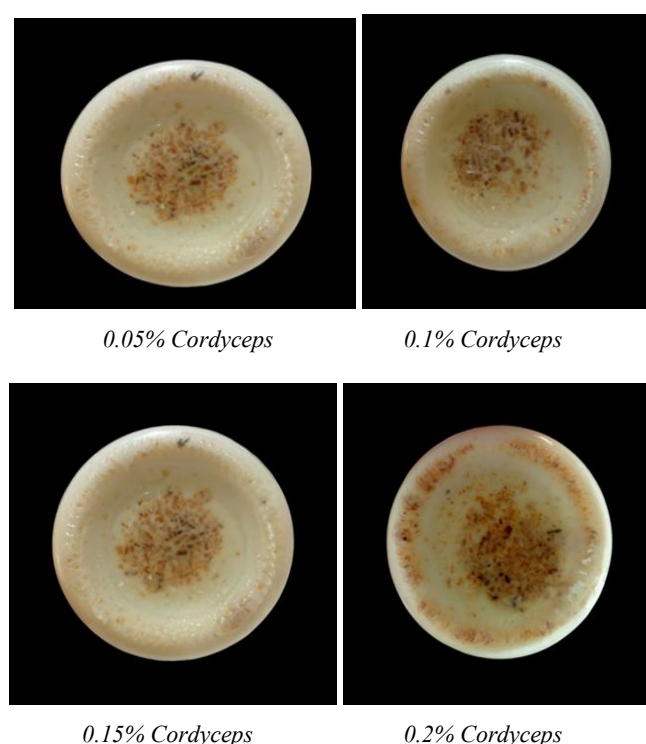


Fig 2: Results of the ratio of *Cordyceps sinensis* added to the structure of yogurt products

Sensory evaluation, the color score ranged from 4.33–4.44, indicating that the addition of *Cordyceps militaris* contributed to improving the natural orange-yellow tone of the product. The addition level of 0.1–0.15% was rated highest by the sensory panel, thanks to the creation of a uniform, bright, and natural light yellow color, originating from the carotenoids and flavonoids contained in the fungus. These pigments not only enhance visual appeal but also have strong antioxidant activity, which helps maintain color stability during storage [17]. However, at higher concentrations (0.2%), the product color becomes darker and less uniform, possibly due to uneven dispersion of mushroom powder in the milk phase, reducing surface smoothness.

The sensory score for texture is highest in the 0.1% sample (4.67 points), then decreases slightly as the mushroom content increases to 0.15–0.2%. This phenomenon reflects the influence of additional solids on the homogeneity and elasticity of the yogurt gel network. At appropriate supplementation levels, *C. militaris* polysaccharides can interact weakly with casein, increasing the perceived

viscosity and smoothness; However, at high concentrations, the gel structure becomes less stable due to uneven dispersion (Lucey, 2002; Huynh *et al.*, 2024).

Thus, the addition rate of *Cordyceps militaris* 0.1% was determined to be optimal for yogurt products, helping to maintain attractive color, smooth texture and harmonious taste without causing significant water separation. This result is similar to recent studies showing that low levels of *C. militaris* addition (< 0.2%) can improve the sensory properties and biological value of yogurt without affecting the protein coagulation process.

Thus, the addition level of 0.1% *Cordyceps militaris* was determined to be optimal for yogurt products, helping to balance structural stability, water retention capacity and sensory value, while contributing to enhancing the biological activity and functional value of the product — in line with the current trend of developing fermented foods rich in natural active ingredients.

4. Conclusions

The study showed that the content of milk powder and cordyceps used has a strong influence on the quality of the product, especially the structure and sensory value. The product when using 14% milk powder gives high sensory value and good structure. Similarly, the amount of cordyceps used is 0.1% also gives similar results. The study is to provide information for the use of biologically active products such as cordyceps in the processing of goat milk products. The study not only brings new nutritional products but also takes advantage of locally available raw materials.

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