

EFFECTS OF SUGARS, ALCOHOLS AND ANTIOXIDANTS ON THE PREPARATION GOAT MILK TABLETS CONTAINING *BIFIDOBACTERIUM BIFIDUM* BB01

– Research paper –

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Abstract: The development of probiotic products has attracted more and more attention. Products made from goat milk powder and probiotics can combine nutrition and health care functions. In this paper, the effects of different sugars, alcohols and antioxidants on the preparation goat milk tablets containing *Bifidobacterium bifidum* BB01 were studied by single factor experiment. The results showed that the appropriate addition of sugars, alcohols and antioxidants were as follows: sucrose 5 %, glucose 1.5 %, xylitol 3 %, ascorbic acid 0.03 %, D-sodium ascorbate 0.09 %, sodium ascorbate 0.03 %, microcrystalline cellulose 0.5 %, D-mannitol 0.1 %. According to the formulation, goat milk tablets with high *Bifidobacterium* activity were developed, and had appropriate hardness, friability and good sensory quality.

Keywords: goat milk tablets; *Bifidobacterium bifidum*; Sugars; alcohols; antioxidants

INTRODUCTION

Goat milk is known as the " king of milk, " which has many functions such as immune regulation, improvement of malabsorption syndrome, reduction of inflammatory bowel disease, reduction of cholesterol, anti-oxidation, and regulation of blood pressure (Liu et al., 2021). In comparison to milk, goat milk has been found to exhibit elevated levels of dry matter, stronger digestive ability and lower allergenicity (Pinto et al., 2017). It is a good source of various bioactive components, a good substitute for milk, and the best substitute for breast milk (Clark et al., 2017). This makes it a suitable ingredient for health care products that can cater to various populations.

Probiotics refer to a class of active microorganisms that aid in promoting the homeostasis of gut microbiota and exert positive impact on the host (Wang et al., 2021). Probiotics are used by the human body after passing through gastric acid, intestinal fluid and other environments in the human digestive tract. There are many kinds of probiotics, and the most widely used probiotics are mainly *Bifidobacterium* and *Lactobacillus* (Areai et al., 2022). Probiotics are widely used in dairy products, and the minimum viable concentration for maintaining probiotic function should be higher than 10⁷ CFU / g (Homayouni et al., 2008). Many

studies have shown that goat milk has a suitable pH value, good buffering capacity and rich nutrients. It can serve as a vector of functional components like prebiotics and probiotics (Li et al., 2023). It can make probiotics such as *Bifidobacterium* grow and maintain vitality during the storage of its products (Bruzantin et al., 2016), providing consumers with sufficient probiotics. Correspondingly, the addition of probiotic strains further enriched goat milk products and improved their nutritional value. However, probiotic strains used in food are generally aerobic or micro-aerobic, so the presence of oxygen in the product may be toxic to microorganisms and cause them to die, resulting in loss of function (Cruz et al., 2007). At this time, the addition of antioxidants is particularly important. *Bifidobacterium* strains are Gram-positive and strictly anaerobic bacteria, which are widely found in human and animal intestines. They mainly include *Bifidobacterium bifidum*, *Bifidobacterium infantis*, *Bifidobacterium breve*, *Bifidobacterium longum*, *Bifidobacterium adolescent* and so on (Areai et al., 2022). *Bifidobacterium* plays an important role in maintaining the intestinal microecological balance, inhibiting the invasion and colonization of pathogenic bacteria, enhancing immunity, reducing cholesterol and anti-aging (Liu et al., 2017). It can also promote the absorption of metal ions, alleviate lactose intolerance, and improve the metabolism of protein, amino acid, fat and vitamin (Khokhlova et al., 2012). The

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physiological activity of *Bifidobacterium* needs to be colonized in the intestine to be exerted, but it is susceptible to adverse environmental factors such as temperature, oxygen, gastric acid and so on (Gao et al., 2023). In order to solve such problems, people usually use microcapsule technology to embed and protect *Bifidobacterium* to reduce its mortality, which has become an important direction of *Bifidobacterium* application research (Caillard et al., 2017). At present, *Bifidobacterium* health products, food, medicine and other fields have been widely used.

In general, prebiotics refer to certain organic substances that cannot be digested and absorbed by the body, but have a selective promoting effect on the growth and activity of probiotics in the intestine, so as to promote the development of the host towards a healthy state, including functional oligosaccharides, polysaccharides, protein hydrolysates, polyols, etc (Al-Khalaifah, 2018). Adding an appropriate amount of prebiotics is a key factor in improving the activity of lactic acid bacteria during fermentation (Delgado-Fernández et al., 2018).

In order to adapt to the new opportunities faced by the goat milk industry, it is necessary to further enrich the types of goat milk products to promote their development. At present, in addition to traditional liquid goat milk and goat milk powder, goat milk products such as goat milk tablets, goat cheese, yogurt, and lactic acid drinks are also pouring into the market. Among them, flaky probiotic solid products have the advantages of convenient carrying and eating, nutritional hygiene, long shelf life and so on. As people are more and more interested in convenient and high-nutrient health foods, goat milk, probiotics, and prebiotics have also received public attention and recognition due to their unique physiological functions and nutritional values. Adding prebiotics and other active ingredients to *Bifidobacterium* goat milk

tablets will help the product develop in a better direction. Therefore, this experiment will explore the components of *Bifidobacterium* goat milk tablets prepared to prepare probiotic goat milk tablets with high activity and stability, which is of great significance to promote the development of China's goat milk industry and will also have broad research value and market prospects.

Probiotics are commonly used functional factors in dairy products. Adding probiotics to goat milk powder can increase the added value of products, enrich the types of goat milk products, and provide consumers with many choices. In recent years, many reports on probiotic milk tablets have been published at home and abroad. For example, Yao et al. (2022) developed *Lactobacillus plantarum* microcapsule milk tablets. Yuan et al. (2013) developed Tibetan mushroom probiotic milk tablets, and He et al. (2018) developed Tibetan kefir probiotic milk tablets, but most of the probiotic milk tablets are processed with milk powder as the main raw material, and there are few reports on goat milk as raw material, and the product variety is relatively simple. Excipients are of great significance for the development of tablets containing probiotics in dairy products. If probiotics and other functional factors are added as excipients on this basis, the probiotic milk tablets not only have all the nutritional value of goat milk, but also have the health care function of probiotics. Compared with the general milk tablets, they have higher nutrition and more complete functions. They not only contain a large number of live *Bifidobacterium*, but also have good flavor and taste. They are health foods suitable for all ages and have great market prospects (Mao, 2021). Secondly, the liquid milk is made into milk tablets, which has the advantages of easy to carry, transport, store, eat and extend the shelf life. Therefore, this paper aims to develop a goat milk tablet that can protect the activity of *Bifidobacterium* to the greatest extent.

MATERIALS AND METHODS

Activation and culture of bacteria

Bifidobacterium bifidum (BB01) used in this study was provided by School of Food Science and Engineering, Shaanxi University of Science and Technology. The *Bifidobacterium* powder preserved in frozen storage was inserted into MRS broth. After activation at 37°C for 20-24h, a small amount of bacterial suspension was taken for microscopic examination. After determining that there were no miscellaneous bacteria, 5% of the inoculation amount was inserted into the liquid medium. After activation for 2 times, it was placed in a refrigerator at 4°C for use. The three activated strains were inoculated into MRS broth with 5%

inoculum and cultured at 37°C for 18h. Man Rogosa Sharpe (MRS) broth is provided by Qingdao Haibo Biotechnology Co., Ltd. All media were sterilized at 121°C for 15 min.

Preparation of freeze-dried powder and *Bifidobacterium* goat milk tablets

The freeze-dried powder was obtained by vacuum freeze-drying technology in MRS broth medium with the addition of screened antifreeze factors (sodium chloride 0.74%, sorbitol 0.08%, glutamic acid 0.02% (Hu, 2012)) and composite freeze-dried protective agents (glycine 5.5%, sodium bicarbonate 0.8%, xylo-oligosaccharides 7%,

arginine 4.5%, skim milk 25% (Hu, 2012)). By calculation, the viable count of freeze-dried bacteria powder can be as high as $(5.2 \pm 0.2) \times 10^{11}$ CFU/g.

The preparation of *Bifidobacterium* goat milk tablets was referred to the method of Azhar et al (2021). Under aseptic conditions, the obtained *Bifidobacterium* powder, goat milk powder and dry powder excipients of different concentrations (sucrose, glucose, xylitol, ascorbic acid, D-sodium ascorbate, sodium ascorbate, microcrystalline cellulose, D-mannitol) were mixed evenly in a three-dimensional moving mixer, and then filled into a 16mm mold. Control the pressure of the single punch tablet press below 8 ± 0.5 KN for tablet pressing, and set the weight of *Bifidobacterium* goat milk tablet at 0.9 ± 0.1 g.

The preliminary in vitro simulation test showed that under the protection of goat milk tablet formula, probiotics could tolerate gastric and intestinal fluid, successfully reach the intestine, and play the role of probiotics (Shu et al., 2020). Therefore, the chewable tablets prepared in this study could effectively avoid the degradation of stomach acid.

Study on the preparation process of *Bifidobacterium* goat milk tablets

Incorporating efficacious excipients can enrich the flavor and elevate the overall quality of the product. By utilizing viable count, hardness, friability and sensory evaluation as four reference values, the development of *Bifidobacterium* goat milk tablets was carried out. The effects of the addition of various excipients (sucrose, glucose, xylitol, ascorbic acid, D-sodium ascorbate, sodium ascorbate, microcrystalline cellulose, D- mannitol) on the product and the optimal process conditions were determined by single factor test.

Determination of viable count

The number of living bacteria is the most important indicator of *Bifidobacterium* milk tablets and it is also the key to ensure that milk tablets have good probiotic effects. In this experiment, determining the number of viable bacteria is a crucial step.

The viable bacteria of BB01 were counted using the high-level agar method. According to the method of partial adjustment (Klayraung et al., 2009), the compressed *Bifidobacterium* goat milk tablets were broken and dissolved in phosphate buffer (pH 6.8), and then diluted with sterile normal saline in a series until the appropriate cell density was obtained. Finally, 1.0mL bacterial suspension was taken and three parts were inserted into an anaerobic tube equipped with sterilized semi-solid medium and shaken well, Incubated at constant temperature for 36-48h. The number of colonies was counted and the number of viable bacteria (CFU/g) was

calculated. The following formula was used to calculate the number of viable bacteria (Eq. 1):

$$Y_1 = \frac{w \times v}{m} \quad (1)$$

where: w - The viable bacteria number per unit of bacterial suspension; v - The volume of bacterial suspension; m - The weight of goat milk probiotic tablets.

Determination of hardness

According to the requirements of the Chinese Pharmacopoeia (2015 edition), the hardness was determined. Three samples of goat milk probiotic tablets with different formulas were taken, and their hardness was measured using the YD-I tablet hardness tester. The hardness value displayed when the milk tablets were crushed by the probe was recorded, and the average value was taken as the test value. The hardness requirement is neither too hard nor too soft, generally controlled between 3.5-8.0kgf (Yang et al., 2015).

Determination of friability

Reference Mao Yaolong determination of friability method (2021), that is, the percentage of weight loss after rolling 100 times in the cylinder of the friability tester (CS-II type), to check its friability. The *Bifidobacterium* goat milk tablets were weighed and put into a clean friability tester. The parameter was set to 100 laps, 25 r / min, and the weight was weighed again after the rotation was completed. The weight loss of the qualified sample should not exceed 1 %, and the following formula was used to calculate friability (Eq. 2):

$$Y_2 = \frac{m_1 - m_2}{m_1} \times 100\% \quad (2)$$

where: m_1 - Weight of goat milk probiotic tablets to be tested at the beginning (g); m_2 - Weight of goat milk probiotic tablets after testing (g).

Sensory evaluation

Bifidobacterium goat milk tablets are eaten after chewing, and the taste, flavor, texture and other sensory qualities of probiotic milk tablets during chewing directly affect the popularity of consumers. Therefore, in order to prepare *Bifidobacterium* goat milk tablets with both nutrition and taste and obtain the best formula combination, sensory evaluation was used as an important evaluation criterion for *Bifidobacterium* goat milk tablets. According to Ma Donglin's sensory scoring rules (2018), 15 randomly selected experienced food researchers were divided into three groups. Milk tablets of different formulations were scored and the scoring results were recorded.

RESULTS

Effect of sucrose on the quality of *Bifidobacterium*-enriched goat milk tablets

Sucrose was mixed with 0.1% bacterial powder, 0.1% goat milk powder and 0.5% microcrystalline cellulose at the ratio of 1%, 3%, 5%, 7% and 9%, respectively. After grinding, dilution, agar tube culture and various indexes measurement. Figure 1 shows the results of viable bacteria number, sensory score, hardness and friability of BB01 goat milk tablets containing different amounts of sucrose. With the sucrose consumption gradually increased from 1 % to 9 %, the hardness and viable count of goat milk probiotic tablets first gradually increased and then gradually decreased, while the friability was opposite. When the sucrose content was 5 %, the friability reached the minimum value of 0.081 %, which indicated that the probiotic tablets met the acceptance criteria according to the Chinese Pharmacopoeia. That is, when the tablets had low friability, they contained the highest number of viable bacteria, had moderate hardness, and received positive sensory evaluations, which was more in line with the public taste and requirements. Therefore, the addition amount of sucrose should be selected at 5 %. Under the condition of adding 5 % sucrose, the sensory score and the number of viable bacteria were the highest. This may be because

sucrose provides the material conditions to promote the growth of bacteria, producing lactic acid, caproic acid, pyruvate, propionic acid, formic acid and other ester flavors with aromatic smells, but too much sugar will cause excessive sweetness and affect the senses (Zhu, 2017). At the same time, the added sucrose provides a carbon source for the bacteria, which increases the number of viable bacteria. Excessive sugar addition will lead to high osmotic pressure, which inhibits bacterial growth and leads to bacterial death (Wang, 2010).

Effect of glucose on the quality of *Bifidobacterium*-enriched goat milk tablets

The proportion of glucose added was 0.9%, 1.2%, 1.5%, 1.8% and 2.1%, respectively. Based on different glucose contents, Figure 2 shows the corresponding results of viable count, sensory evaluation, hardness and friability. Glucose can be considered as a sweetener, which can not only increase the nutritional value of milk probiotic tablets, give milk probiotic tablets sweet taste, but also enrich the flavor of milk probiotic tablets (Lee et al., 2016), increase the friability of milk probiotic tablets, avoid its too hard to affect the taste, and then improve the sensory score of milk probiotic tablets.

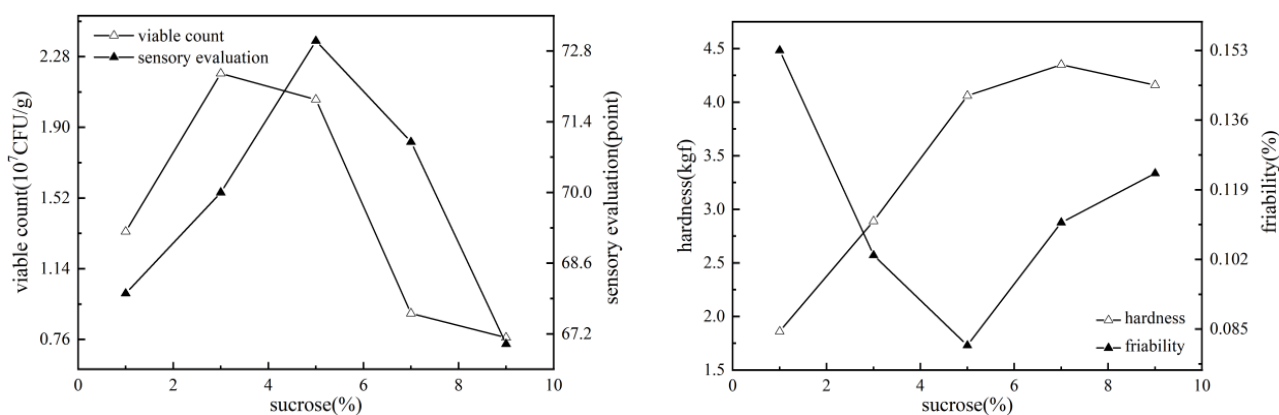


Figure 1. Effect of sucrose on BB01 goats' milk tablet

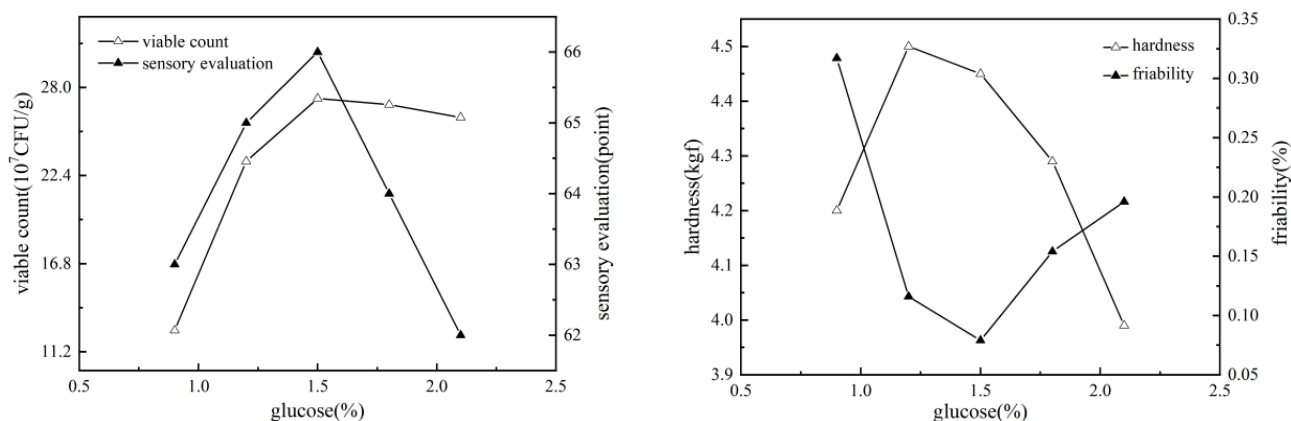


Figure 2. Effect of glucose on BB01 goats' milk tablet

As detailed in Figure 2, with the glucose consumption gradually increased from 0.9% to 2.1%, the hardness and viable count of goat milk probiotic tablets first gradually increased and then gradually decreased, and its friability first gradually decreased and then gradually increased. When the formula contained 1.5% glucose, the friability of goat milk probiotic tablets reached the minimum value of 0.079%, the hardness was slightly different from the maximum value, and the viable bacteria count per unit of milk probiotic tablets and sensory evaluation reached the maximum value. Probiotic functional products primarily rely on the quantity of viable bacteria as the main evaluation index. Based on the original nutritional value of the milk probiotic tablets, the primary consideration in the development of probiotic emulsion tablets is to increase the quantity of viable bacteria. Therefore, the hardness and friability of the milk probiotic tablets are 0.31%, which are in line with the physical and chemical indicators, and the sensory evaluation is also in line with the consumer taste and requirements. Therefore, it can be determined that the amount of glucose added was 1.5%.

Effect of xylitol on the quality of *Bifidobacterium*-enriched goat milk tablets

The proportion of xylitol added was 1%, 2%, 3%, 4% and 5%, separately. As shown in Figure 3, BB01 goat milk tablets containing different xylitol levels were tested for the number of viable bacteria, sensory evaluation, hardness, and friability. Xylitol is a natural and healthy sweetener. It can make the sweetness of milk probiotic tablets more abundant, and it does not require the participation of insulin in the metabolic process of the body, and will not lead to an increase in blood glucose. It can also give the tablet a cool taste and has a certain throat moistening effect (Zhao et al., 2020). In addition, xylitol also has the effects of promoting the growth of probiotics and preventing dental caries (Hu, 2012). With the gradual increase of the amount of xylitol added, the hardness, viable bacteria number and sensory evaluation of goat milk probiotic tablets

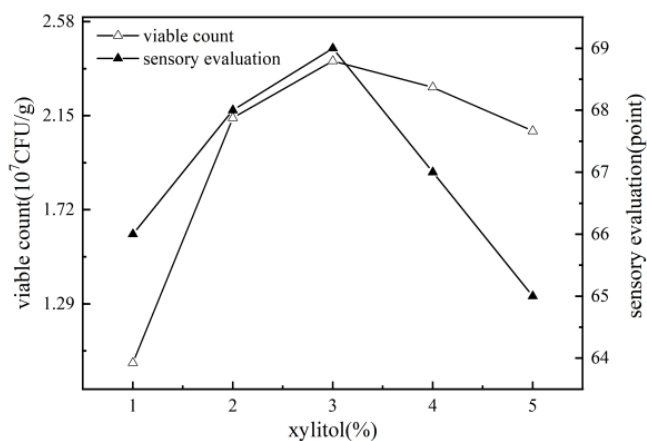


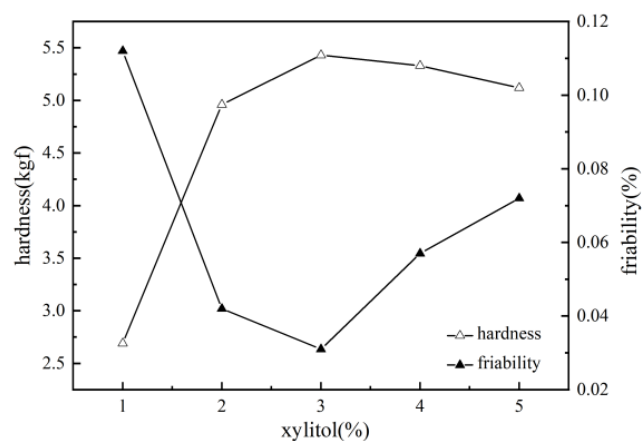
Figure 3. Effect of xylitol on BB01 goats' milk tablet

initially increased and then gradually decreased, and the friability showed the trend of decreased rapidly and then increased. It may be that when the amount of xylitol is insufficient, the cool feeling of milk probiotic tablets is weak and the taste is poor. When the dosage is too much, the consumption of xylitol by *Bifidobacterium* is reduced, which will cover up the unique fragrance of milk flakes and make the taste greasy. When the addition amount of xylitol was 3.0%, the goat milk probiotic tablets exhibited a hardness of 5.43kgf, the viable cells number of milk probiotic tablets was 2.41×10^7 CFU / g, which reached the maximum value, and the friability was 0.03%, which also reached the minimum value, and the sensory evaluation was better. Therefore, when the xylitol addition was 3%, the viable count, hardness and friability of the milk probiotic tablets met the physical and chemical indicators, and also met the taste and requirements of consumers.

Effect of ascorbic acid on the quality of *Bifidobacterium*-enriched goat milk tablets

The other factors were kept constant, and the amount of ascorbic acid was 0.01 %, 0.03 %, 0.05 %, 0.07 % and 0.09 %, respectively. Figure 4 shows the viable count, sensory evaluation, hardness and friability results obtained by measuring goat milk probiotic tablets with different ascorbic acid additions.

Ascorbic acid is a natural antioxidant that is allowed to be added to foods. As detailed in Figure 4, when the addition amount of ascorbic acid gradually increased from 0.01 % to 0.09 %, the friability of goat milk probiotic tablets gradually decreased and then gradually increased, and the hardness and the viable counts initially increased and then decreased. This may be related to the continuous decrease of pH value, which leads to H^+ entering cells and inhibits the growth of c. Under acid stress, cysteine, γ -glutamyl cysteine, and BCAA, etc. can be added to enhance the acid tolerance response mechanism of *Bifidobacterium* and improve its acid resistance (Junhua et al., 2012).



When the addition amount of ascorbic acid was 0.03 %, the goat milk probiotic tablets exhibited a hardness of 4.92kgf, the viable cells number was 1.92×10^7 CFU / g, which reached the maximum value, while the friability was slightly different from the minimum value, and the sensory evaluation was also better. Therefore, the amount of ascorbic acid added was 0.03 %.

Effect of D-sodium ascorbate on the quality of *Bifidobacterium*-enriched goat milk tablets

Each proportion of D-sodium ascorbate added was 0.05%, 0.07%, 0.09%, 0.11%, and 0.13%. Figure 5 shows the viable count, sensory evaluation, hardness and friability results obtained by measuring goat milk probiotic tablets with different D-sodium ascorbate additions.

D-sodium ascorbate is a commonly used antioxidant in dairy products, which can promote

the growth of probiotics (Twetman, 2010). In addition, D-sodium ascorbate also has a certain color protection effect (Shi et al., 2022). As detailed in Figure 5, when the addition amount of D-sodium ascorbate gradually increased from 0.05% to 0.13%, the hardness and viable count of goat milk probiotic tablets initially increased and then gradually decreased, and the friability reached the lowest value and then continued to increase. When the addition amount of D-sodium ascorbate was 0.09%, the goat milk probiotic tablets exhibited a hardness of 4.72kgf, and the viable cells number of milk probiotic tablets was 1.0×10^7 CFU / g, both of which reached the maximum value, and the sensory evaluation was better. Therefore, D-sodium erythorbate is helpful for the growth or survival of *Lactobacillus acidophilus*, thus contributing to the extension of the shelf life of milk probiotic tablets.

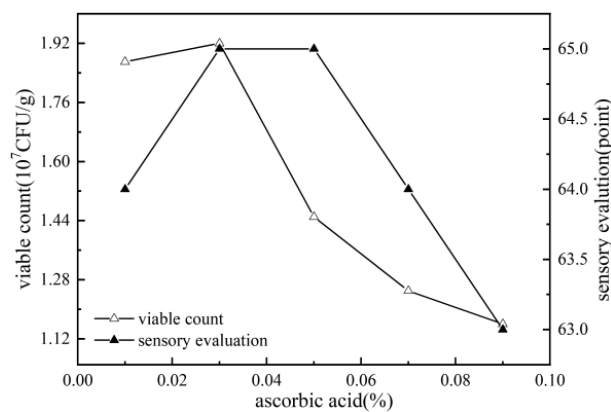


Figure 4. Effect of ascorbic acid on BB01 goats' milk tablet

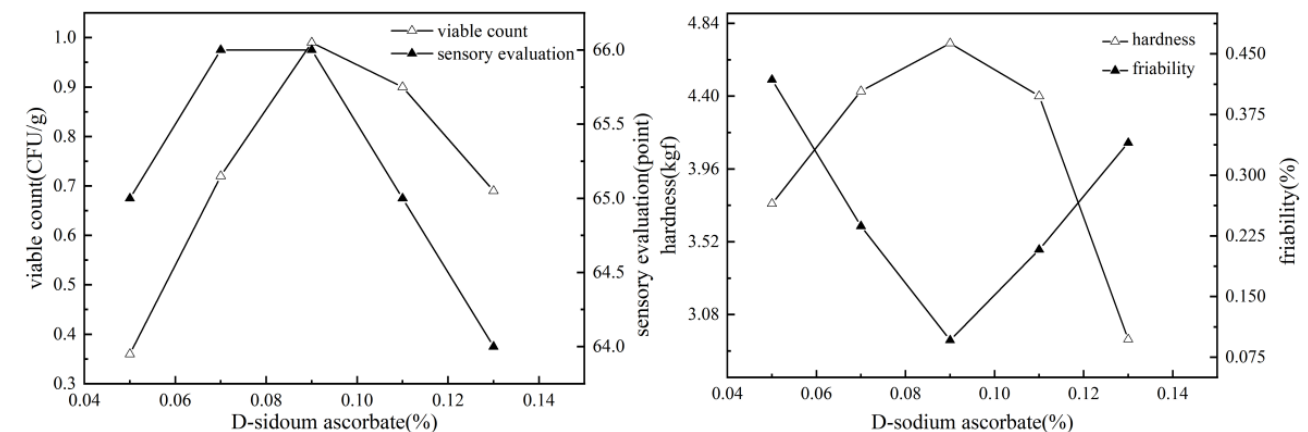


Figure 5. Effect of D-sodium ascorbate on BB01 goats' milk tablet

Effect of sodium ascorbate on the quality of *Bifidobacterium*-enriched goat milk tablets

The experimental study was carried out with 0.01 %, 0.03 %, 0.05 %, 0.07 % and 0.09 % sodium ascorbate. In Figure 6, the number of viable *Bifidobacterium* cells, sensory evaluation, hardness,

and friability of goat milk tablets containing different amounts of sodium ascorbate are depicted. Studies have found that sodium ascorbate can effectively eliminate the oxidative stress of *Bifidobacterium* and increase the number of viable bacteria by about twice. The mechanism of action

may be to transform toxic metabolites (superoxide or H_2O_2) through chemical reactions, thereby creating a good environment for the growth of *Bifidobacterium* (Zhao et al., 2008). As detailed in Figure 6, when the addition amount of sodium ascorbate gradually increased from 0.01 % to 0.09 %, the hardness, viable count and sensory evaluation of goat milk tablets showed a trend of increasing and then decreasing, but its friability has always increased. When 0.03 % sodium ascorbate was added, the viable cells number of *Bifidobacterium* goat milk tablets reached the highest value of 2.8×10^7 CFU / g, and had a good performance in the senses. At this time, the hardness reaches 3.73kgf and the brittleness is 0.18 %. In order to obtain an optimal evaluation index of viable bacteria count, 0.03% sodium ascorbate should be added.

Effect of microcrystalline cellulose on the quality of *Bifidobacterium*-enriched goat milk tablets

There were 0.1%, 0.3%, 0.5%, 0.7%, and 0.9% microcrystalline cellulose additions. The comparison of parameters of goat milk probiotic

tablets containing different amounts of microcrystalline cellulose is shown in Figure 7. Microcrystalline cellulose is a crystalline powder with a small degree of polymerization composed of porous particles. Microcrystalline cellulose is a commonly used food filler, which can improve the consistency, taste and sensory quality of products. As a tablet excipient, microcrystalline cellulose has good compressibility, strong binding force, high hardness of pressed tablets, and also has the advantages of adhesion and flow aid (Nsor-Atindana et al., 2017). However, excessive addition will cause disintegration (Zhang et al., 2013). Furthermore, the simulated gastric juice test conducted on milk probiotic tablets revealed a rapid decline in viable bacteria count in those without microcrystalline cellulose, whereas the addition of microcrystalline cellulose resulted in a more compact tablet structure (Kinjal et al., 2019), providing a protective barrier to preserve the probiotics within. As detailed in Figure 7, when the addition amount of microcrystalline cellulose gradually increases from 0.1% to 0.9%, the number of living bacteria, sensory score and hardness of the milk probiotic tablets initially increased and then gradually decreased.

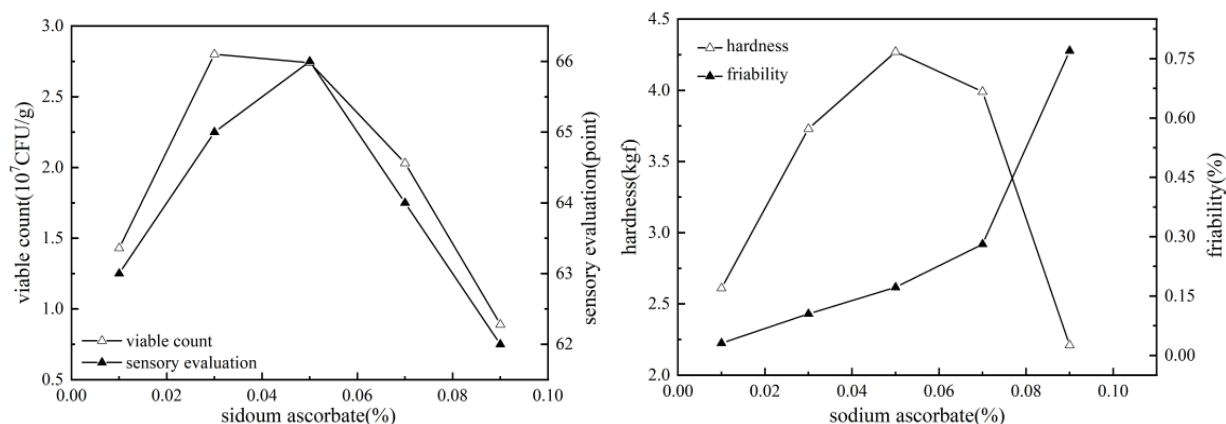


Figure 6. Effect of ascorbic acid sodium on BB01 goats' milk tablet

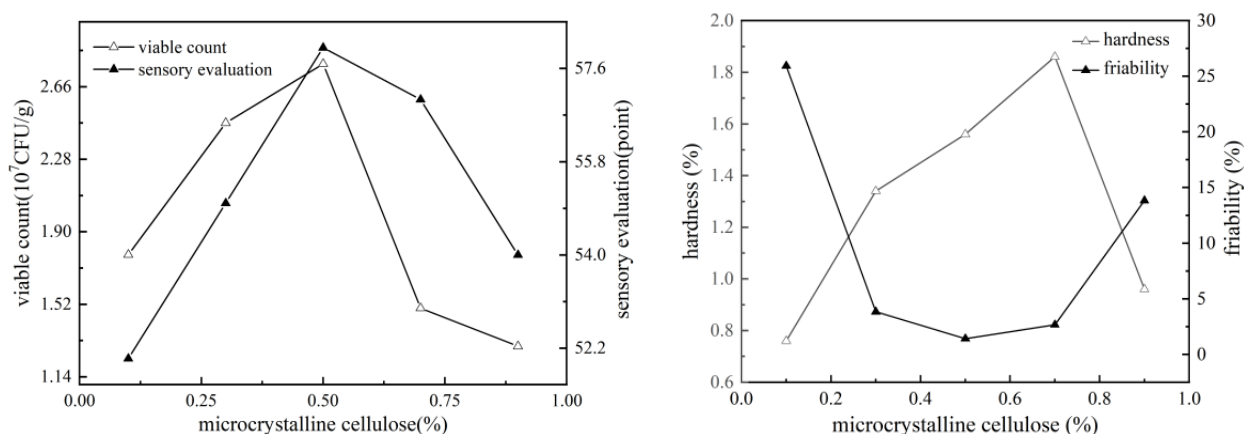


Figure 7. Effect of microcrystalline cellulose on BB01 goats' milk tablet

After the friability decreased to a certain value, it basically maintained at the same level, and then suddenly increased. The decrease was due to the fact that microcrystalline cellulose was a plastic excipient. Once deformed, it was not easy to elastically recover. The increase was due to the high content of microcrystalline cellulose, and its hygroscopicity was reflected (Liu et al., 2022). When the addition amount of microcrystalline cellulose was 0.5%, the friability of goat milk slices was 0.57%, the quantity of live bacteria reached a maximum of 2.78×10^7 CFU / g, and the sensory score was also the most appropriate. The hardness was 3.88kgf, although it did not reach the maximum value, the total sensory requirements of the milk slices were better. Thus, 0.5% microcrystalline cellulose was the optimal addition amount.

Effect of D-mannitol on the quality of *Bifidobacterium*-enriched goat milk tablets

The content of D-mannitol in goat milk probiotic tablets was set as 0.1%, 0.3%, 0.5%, 0.7% and

0.9%, respectively. Figure 8 shows the determination results of each index of goat milk probiotic tablets with different D-mannitol contents. D-mannitol has a certain sweetness and good compression properties. It absorbs heat when it dissolves in the mouth, giving a cool taste. With the increase of the amount of addition, the flavor and the appearance of the product such as finish can be significantly improved (Yang et al., 2018). As can be seen from Figure 8, when the addition of D-mannitol gradually increased from 0.05% to 0.8%, the viable bacteria number and hardness of goat milk probiotic tablets first increased rapidly to an obvious peak and then decreased continuously, while the friability did not change initially, and then suddenly increased. The number of viable *Bifidobacterium* could reach 0.46×10^7 CFU / g, the hardness of goat milk probiotic tablets was moderate, the friability was low, and the sensory evaluation was at its optimum when 0.1% mannitol was applied

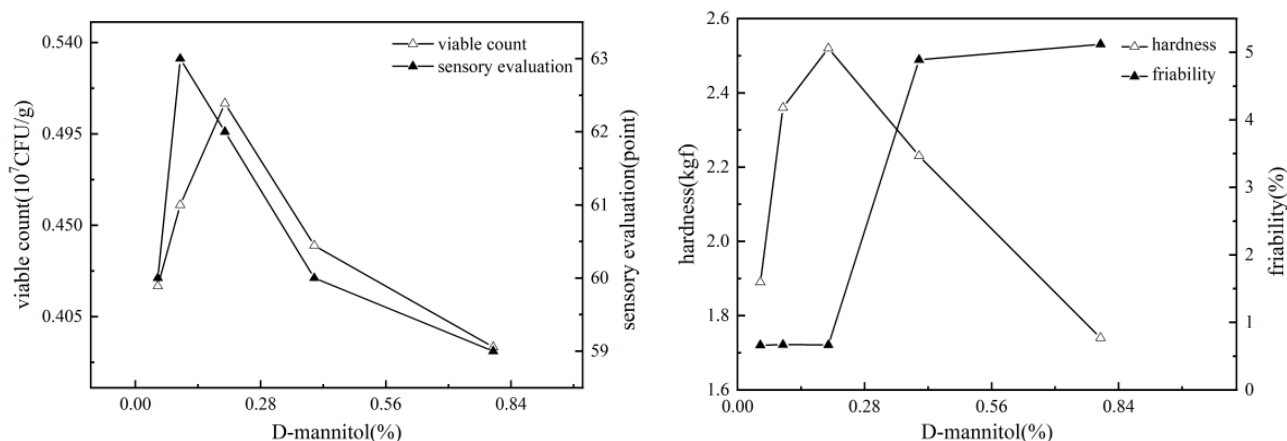


Figure 8. Effect of mannitol on BB01 goats' milk tablet

DISCUSSION

The addition of appropriate excipients can effectively protect the vitality of *Bifidobacterium*. In this study, the viable bacteria count, hardness, fragility and sensory evaluation of *Bifidobacterium* goat milk tablets were taken as reference indexes to optimize the product formulation, and the viable bacteria count of the products showed the maximum value under the optimal supplemental amount of each excipient, which was similar to the formula of goat milk tablets containing *Lactobacillus acidophilus* previously explored by Ma Donglin (2018). All of them have excipients such as sucrose, glucose and xylitol, and *Bifidobacterium* goat milk tablets have lower brittleness. Although all the indexes could meet the standards, it still had a certain distance to become a best-selling product, and its comprehensive quality still had a large room

for improvement, mainly to improve the stability of cell viability, because it was an important index representing the protective effect of probiotic goat milk tablets on cells and shelf life. Therefore, at the early stage of milk tablet preparation, probiotics can be modified by genetic engineering or screened in the direction of oxygen resistance, acid resistance and easy accumulation of trace elements necessary for human body. For example, Shu et al (2020) screened a strain with good selenium-enriched ability, namely *Lactobacillus rhamnosus* L20, and found that the corresponding goat milk powder and tablets produced by it showed considerable storage stability. Adding selenium-enriched probiotics to food can increase the nutritional value of food and augment the health-promoting benefits imparted by selenium-enriched probiotics on the human body.

Suitable packaging containers can also be selected and microcapsule technology can be used to protect live bacteria. Studies have demonstrated that aluminum foil bags exhibit a lower oxygen permeability rate and are more effective in preventing light exposure compared to plastic bottles, so they are more suitable for preserving probiotic goat milk tablets (Shu et al., 2020). Bernucci et al (2017) used skim milk as the substrate, and emulsified starch or chitosan with alginate. The microcapsules prepared by spray drying method can protect *Bifidobacterium* and improve the integrity of cells, which can be applied to food. Moreover, biopolymer mixture was more effective than single biopolymer encapsulation of probiotics (Klayraung et al., 2009). If the *Bifidobacterium* microcapsules made by adding goat milk, cow milk or inulin to the wall material can improve the stability of the microcapsules, promote the protective effect of the microcapsules

on the *Bifidobacterium*, and enhance the survival rate of the *Bifidobacterium* microcapsules during cold storage (Prasanna et al., 2018). Kavas et al (2021) confirmed through experiments that the addition of prebiotics to microcapsules can retain a higher level of probiotic activity. Huq et al (2016) studied tablet formulations of probiotics and found that the combination of pectin, sodium alginate and cellulose nanocrystals as excipients played an important role in maintaining the activity of *Lactobacillus rhamnosus*. In addition, on the basis of the original formula, oligosaccharides (fructo-oligosaccharides, isomaltose oligosaccharide, etc.) can be added to promote the growth of probiotics and regulate antibacterial activity (Pranckutė et al., 2016), or to add tea polyphenols, alkaloids, proteases and other functional factors, so as to improve the product quality and make it develop in a direction more conducive to human health.

CONCLUSIONS

The effects of different types and contents of sugars, alcohols and antioxidants on the four reference indexes of viable count, hardness, friability and sensory evaluation of *Bifidobacterium* goat milk tablets were different. In this study, the optimal content of each component in the preparation of *Bifidobacterium* goat milk tablets was determined by single factor test: sucrose 5 %, glucose 1.5 %, xylitol 3 %, ascorbic acid 0.03 %, D- sodium ascorbate 0.09 %, sodium ascorbate 0.03 %,

microcrystalline cellulose 0.5 %, D-mannitol 0.1 %. The prepared goat milk tablets had high viable *Bifidobacterium* count, suitable hardness and friability, and good sensory evaluation. These results are helpful for further optimizing the formulation of *Bifidobacterium* goat milk tablets by principal factor screening and response surface methodology, so as to provide valuable insights for the industrial production of milk tablets to meet consumer demands.

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