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Investigating the effect of using grape pomace powder to produce functional fruit filling containing *Bacillus coagulans* on the physicochemical and sensory characteristics of flour pastry

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ABSTRACT

Given the increasing demand for functional food products and the importance of enhancing sensory and health-related properties of pastries, in this research, the production of functional fruit filling was investigated using grape pomace as a substitute for pectin and grape syrup as a natural sweetener that contained *Bacillus Coagulans* probiotic bacteria. Different amounts of grape pomace (2.5, 0.5, 7.5, and 10 g) were replaced by pectin. The grape syrup was used as a natural sweetener and 2 strains of *B. Coagulans* probiotic bacteria were used to functional the filling. The filling produced in the pastry formulation was used and then subjected to simulated gastrointestinal conditions (stomach and small intestine). The survival percentage of both strains present in the fruit filling in the in vitro conditions of the digestive system was higher than 90 %, which showed that filling can be an important food not only for carrying *Bacillus* species throughout their useful life but also for potentially guaranteeing their survival in the conditions of the digestive system. The results of the sensory evaluation showed that the overall acceptance of fillings containing grape syrup and *B. Coagulans* (4.53) was higher than normal filling (4.29). The results of this research showed that it is possible to produce probiotic filling with natural sugar by using grape pomace, grape syrup, and *B. Coagulans* probiotic bacteria, which leads to the value of the by-products of the food industry.

1- INTRODUCTION

Jam-filled nuts (fruits)¹It belongs to a group of fruit-based products that are prepared from fruit raw materials, sugar, water and stabilizing agents and are used in various products such as cakes, donuts, etc. The sensory quality of jam fillings includes characteristics such as sweet and sour balance, color, fruit flavor, medium firmness and homogeneous gel-like texture. One of the components of jam filling formulations is hydrocolloids such as pectin [1]. Pectin offers a wide range of functional properties that can improve viscosity, gel strength, texture, cooking stability and thermal properties with longer shelf life. The use of hydrocolloids can also help produce healthier food products by reducing the use of sugar, fat and other less healthy ingredients while maintaining the desired sensory properties of the fillings. Overall, the use of hydrocolloids in jam filling production has significant potential to improve their quality and performance and can provide a wide range of benefits to both producers and consumers [2]. Today, the use of waste and by-products of the food industry as rich sources of bioactive compounds and suitable for use in the formulation of various food products such as jam nuts has received attention.

grape (*Vitis vinifera*) is one of the most widely cultivated products in the world. The processes related to the grape processing industry generate a large amount of by-products and waste, which currently pose environmental and economic sustainability problems for companies in this sector. For this reason, solutions are being investigated to develop new high-value-added products that derive from the valorization of these residues [3]. One of the wastes produced in the grape processing industry is grape pomace, which is rich in valuable compounds such as polyphenols (anthocyanins, flavonols, flavan-3-ols, procyanidins), phenolic acids, resveratrol, and pectin. Grape pomace is usually used to extract tartaric acid and colorants such as anthocyanins. In addition to the real benefits associated with grape pomace reuse, such as high efficiency in disposal management and enrichment of bioactive molecules and

antioxidant substances [3], recent attention has been paid to the applications of grape pomace for the production of extracts with antioxidant properties, fermentation substrates, composting, and biomass for energy production [4].

High fructose corn syrup (HFCS)²Due to their suitable technological properties, they are used as a sugar substitute. Today HFCS It is used in bakery products, dairy products, breakfast cereals and beverages, but it has been reported that there may be a direct relationship between high fructose consumption and adverse health effects such as obesity and metabolic syndrome. Many reports published about its harmful properties on human health have led researchers to conduct studies in order to replace it with natural sweeteners. One of the cases that has shown favorable properties is various fruit juices such as grape juice [5].

Today, food is not just considered as a nutritional component. The general perception is that food has a direct impact on a person's health. In fact, food not only has the ability to satisfy hunger, but also has the additional ability to improve physical and mental health. Given the increase in life expectancy and the increasing health care costs associated with the aging population, so-called functional foods³It has gained popularity among health-conscious individuals. The term "functional" is often used to refer to food products that have specific health benefits and are beneficial to the human body in some way. Some functional foods are made by altering processing methods or adding chemicals to foods. When it comes to bioactive components, the properties of a product can be customized to treat a disease or help improve overall health. Functional ingredients in foods can include the addition of various phytochemicals such as antioxidants, vitamins, fibers, minerals, omega-3 fatty acids, or live cells of probiotic microorganisms. Probiotics are described as live bacteria that, when consumed in sufficient quantities, can prevent various diseases and strengthen the host's immune system by maintaining the balance of microorganisms in the human digestive tract [6, 7]. Grape pomace has been studied in various studies so far [8, 9], but its effect as a substitute for pectin and the use of grape juice as a HFCS in the formulation of jam

1- Fruit filling

2-High-Fructose Corn Syrup

3- Functional food

nuts, they have not been studied so far, which is why grape juice was used as a natural sweetener in the present study. Due to its unique life cycle in the digestive tract and probiotic effects, *Bacillus Coagulans* It has shown great potential in the treatment of various human diseases. For example, through direct regulation or indirect modulation by the host microbiota, *Bacillus coagulans* It plays a significant role in eliminating infections and reducing gastrointestinal diseases and even diseases of distant tissues. In addition, the ability *Bacillus coagulans* In maintaining homeostasis of the host microbiota, it can help digest daily meals and promote intestinal health [10]. Although various studies have been conducted on the use of bacteria *Bacillus coagulans* has been carried out in various products such as tea [11, 12], snacks [13], pasta [14] and curd [15], this is the first time that probiotic bacteria have been used *Bacillus coagulans* It has been used as a probiotic functional product for the enrichment of jam fillings and the production of flour confectionery. Therefore, the aim of this study is to produce a functional jam filling using grape pomace as a substitute for pectin and grape juice as a natural sweetener, which contains probiotic bacteria. *Bacillus coagulans* They are, is.

2-Materials and methods

2-1-Preparation of grape pomace powder (GPP)

65 kg of varietal grapes *Vitis Vinifera*⁵ It was collected directly from Malayer County (harvest season 1401) located in Hamedan Province. The grapes were washed using water and then pressed

and the pulp was separated after extracting the grape juice. The juicy pulp was dried for 4 hours in an oven (D-2, Sveba Dahlen, Fristad, Sweden) at 60°C. Finally, the grape pomace was ground using a mill (GCS2700, Iran) was ground and 80% of the particles passed through 200 mesh.

2-2-Preparing jam filling with grape pomace powder

Samples in a food processor (Qbo8, Roboqbo (Italy) equipped with temperature and stirring speed control were prepared according to the method of Carselli et al. (2022) with minor modifications [16]. The first step in sample preparation was to distribute the pectin well in the sugar and add it to the mixture. HFCS (with Brix 77), glycerin, sorbitol syrup 70%, which was previously heated to 60 °C and spun for 5 minutes at 70rpm was stirred. Then the temperature was increased to 80°C to completely dissolve the sugar and pectin. Calcium chloride was dissolved in a small amount of water and added to the mixture containing pectin and stirring was continued for another 5 minutes. In the final step, pH The pH was adjusted to 3.8 using citric acid solution (1:2 citric acid to water ratio) and stirring and heating were continued for another 5 minutes. To prepare treatments containing GPP were, pectin was not added. Levels GPP The used ones are given in Table 1. The samples were transferred to different plastic containers and stored for 24 hours at 8°C (freshly prepared samples). After 24 hours, half of each jam treatment was baked at 200°C for 10 minutes. Before performing the desired tests, the samples were stabilized for 1 hour at room temperature.

Table 1. Formulation of fruit fillings prepared in the present study

Ingredients	HFCS 55%	Glycerin	Sorbitol syrup 70%	Sugar	High-methoxy Pectin	GP P	Citric acid
Total (g)= 107	44.2	35	10	10	0	7.5	0.3

2-3-Preparation of jam filling containing grape juice

A jam core containing grape pomace and grape juice was produced based on our previous results [17]. In order to produce grape juice, first the grapes were cleaned and dewatered. Then the produced grape juice was mixed with white soil in a ratio of 1:10 and stirred until the foam

disappeared. The resulting mixture was stirred. Then it was left for 6 hours to settle the soil. Settle down. In the next step, the soil was separated from the grape juice using a multi-layered cloth. Finally, the grape juice was filtered and heated to obtain grape juice with a Brix of 70. The jam core formulation was prepared as in step 2-2. To prepare jam core from grape juice

(20.785%), HFCS (421.11 percent) and sorbitol syrup (99.5%). These values were based on the optimal response of maximum tissue softness using the simplex lattice design.⁶ Selected.

2-4- Functional Jam Brain Preparation

2-4-1- Cultivation *Bacillus coagulans*

In order to obtain spores from commercial strains *Bacillus* (*Bacillus Coagulans* BC99 and *Bacillus Coagulans* FC) First, the plants were grown in nutrient broth medium.⁷ They were grown at 37°C for 2 days and the active cultures were transferred to 50 ml of nutrient broth medium and incubated at 37°C for 12 hours. Then, the cultures were transferred to 250 ml of sporulation medium (0.2% glucose, 0.05% sulfate). Nizim 7 water, 0.6% dipotassium hydrogen phosphate, 0.5% meat extract, 0.3% peptone) and incubated at 37°C for 5 days. After incubation, the cultures were kept at 80°C for 15 minutes and then washed with distilled water. For this purpose, the cultures were centrifuged at 4°C and 5000 rpm for 15 minutes and the spores were precipitated. After that, the supernatant was discarded and the precipitate was washed with 10 ml of sterile distilled water and centrifuged again. This process was repeated 3 times. Then the obtained precipitate was dissolved in 5 ml of sterile distilled water and stored at 4°C for use in the next steps [18].

2-4-2- Jam-like brain formulation containing probiotic bacteria

After producing a jam base with grape juice, HFCS and fructose syrup in the second stage, jam core containing probiotic bacteria was produced in this stage. Commercial strains *Bacillus coagulans* was used as a probiotic bacteria to produce a functional product. A jam core was produced similar to the previous step. For this purpose, before the final cooking step, bacterial spores (10^8 - 10^{10} Spore *Bacillus* per 500 g of product) were added to the mixture at a temperature of 45-50 °C [18].

To prepare flour cookies, first, fat (9%), sugar (12%), and soy lecithin (0.15%) were mixed by a mixer (2z, Tabriz Machine Rotation, Iran) for 5 minutes at a speed of 40 rpm, and then bicarbonate was added.- Monium (0.6%) and

water (17%) were added and mixed for 2 minutes at 30 rpm. Finally, flour (60.83%) was added along with protease enzyme (0.02%) and salt (0.4%) and mixed for 10 minutes at 40 rpm. The final dough was then drained and allowed to rest for 10 minutes until ready to use. The dough was poured onto it using a wide roller and a jam filling at a ratio of 30 to 70%, and another layer of dough was placed on top of the jam filling. The flour pastry samples were baked for 9 minutes at 200°C. Various tests were performed on the samples after they had cooled.

2-4-3- Evaluation of the viability of strains *Bacillus*

Probiotic strains *Bacillus* were measured in the culture medium. The diluted samples were placed in nutrient agar by the dropwise method and the Petri dishes were incubated at 37°C for 24 hours. The survival of the species *Bacillus* The shelf life of flour confectionery was determined up to 12 months at room temperature.

2-4-4- Extra-vitro simulation of gastrointestinal conditions

Analysis of the stability of microorganisms in the digestive tract under conditions It was ⁸ *برون-تنی* determined according to the method recommended by Biuriti et al. (2010) [19]. 10 g of the sample was exposed to treatment with solutions of pepsin (3 g/L) and lipase (0.9 g/L) with pH was adjusted to 2 with the help of sterile 1 M hydrochloric acid solution to simulate the gastric phase. To simulate the first intestinal phase, bile salts solution (10 g/L) and pancreatin (1 g/L) were added and pH It was adjusted to 6.5 using an alkaline solution (150 ml of 1 M sodium hydroxide solution per liter, 14 g of monosodium phosphate). Finally, to simulate the second phase of the intestine, 10 g/l of bile salts and 1 g/l of pancreatin solution were added after adjustment. pH Zinc 2.7 was added to the samples again. Each solution of the three phases was kept for 2 hours at 37 °C in a shaker. For spore counting, 1 ml of the solution was collected at the initial time and after 6 hours and placed on nutrient agar for counting. The survival rate of probiotic strains at the initial time and after a specified time was calculated based on equation 1:

6-Simplex lattice

7-Nutrient broth

8-In vitro

$$\text{Survival (percentage)} = \frac{\text{Determine the time elapsed after the number}}{\text{Initial time in number}} \times (1) \quad (1)$$

100

Stability analysis in conditions *بیرون-تنی* The digestive tract was examined during the storage period.

2-4-5-Detect the presence of probiotic bacteria

To detect the presence of probiotic bacteria, the bacterial strain was combined with fluorescein dye, added to the brain, and examined under a fluorescence microscope at a wavelength of 521 nm. At this wavelength, the fluorescein dye reflects green light.

2.6- Sensory evaluation

In order to evaluate the sensory characteristics of the jams produced, 20 trained evaluators were used at Zarnam Company, 10 of whom were female and 10 were male. The evaluators' ages ranged from 27 to 51 years. The samples were presented to the evaluators in sealed, odorless plastic containers with three-digit random numbers at room temperature. The evaluators were asked to examine the samples and evaluate the characteristics of color, odor, taste, texture, and overall acceptability using a five-point hedonic scale (from 1 = unacceptable to 5 = very acceptable).

2-7-Statistical analysis

The tests were conducted in a completely randomized design. Analysis and evaluation of variance⁹(ANOVA) using statistical software¹⁰SAS At the 95% confidence level and Duncan's multiple range test¹¹To confirm the existence of differences between the means, all measurements of these sections were performed in triplicate.

3-Results and Discussion

3-1-Nutritional properties of probiotic jam in flour confectionery

3-1-1-Stability of probiotic bacteria during product storage

Two-strain probiotic bacteria count *Bacillus coagulans* in the jam kernels produced are shown in Table 2. According to the results, a decrease of approximately 2 logarithmic units in the number of microorganisms was observed during the production process. The minimum number of probiotic microorganisms required to provide health benefits to the consumer should be more than CFU/g 10⁶[18]. According to the results of bacterial counting on the first day, it was observed that the jam samples had reached the required level. In the case of jam samples containing *Bacillus coagulans BC99* Number of colonies log CFU/g 11/8 and for the strain *Bacillus coagulans FC* Equal to log CFU/g was 6.61, which after 12 months of storage, these values were log CFU/g 08/7 and log CFU/g 81.5 received. Jam nuts containing strain *Bacillus coagulans BC99* It has maintained its probiotic properties throughout the storage period. However, the number of strains *Bacillus coagulans FC* was lower than desired. Since the production of jam kernels is carried out at high temperatures, it is very important to maintain the viability of probiotic bacteria used in the product formulation during production and storage. Bacterial spores are produced as a means of survival under extreme environmental conditions [20]. Thermal stability and the ability of strains *Bacillus* To survive in harsh conditions, they have become a suitable option for use in various food formulations [21]. Dacostacardoso et al. (2024) used flour containing bacteria *Bacillus Coagulans* They used it to produce porridge. The survival of the probiotic until the end of the storage period was high. log CFU/g was 7.13 [22]. Angul et al. (2023) used dried grape pomace containing probiotic lactic acid bacteria as a sugar substitute and reported that the probiotic survival rate after 14 days of storage at 4°C was 13.7% in dry weight. log CFU/g 7 has arrived [8].

Table 2. The count of *B. Coagulans* in different fruit fillings during storage at room temperature (LogCFU/g)

Treatments	Before	After cooking (at 45-50 °C) and during storage
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9-Analysis of variance

11-Duncan

10-Statistical Analysis System

	cooking (4 °C)	Day 1	Month 3	Month 6	Month 12
Control	0	0	0	0	0
BC99	1.08 ±0.15 ^{Eb}	8.11 ±0.25 ^{Aa}	7.86 ±0.20 ^{Not}	7.59 ±0.09 ^{That}	7.08 ± 0.07 ^{And}
FC	8.45 ±0.06 ^{Aa}	6.61 ±0.45 ^{Bb}	6.01 ±0.13 ^{ACb}	5.93 ±0.17 ^{CDb}	5.81 ± 0.15 ^{Db}

Different lower- and upper-letter indicate statistically significant differences ($p < 0.05$) between samples at the same time and the same sample at various times.

3-1-2-Sustainability of species *Bacillus* In vitro gastrointestinal tract

Resistance to enzymes and pH Simulated stomach and intestinal fermentation is one of the most recommended in vitro tests for evaluating the probiotic potential of microbial strains [19, 23, 24]. Controlling the tolerance of probiotic microorganisms in the final product to digestive conditions can help in selecting the appropriate feedstock, especially for bacteria that are more sensitive to digestive conditions, and may also be effective in increasing their survival [19, 25]. The survival rate of strains *Bacillus* The properties of probiotics added to jam kernels exposed to in vitro conditions of the gastrointestinal tract during the product storage period were determined (Table 2). The survival percentage of both probiotic strains *Bacillus* The content of probiotics in jam kernels was above 90% throughout the study period. In a study conducted by Suarez et al. (2019) in which probiotic bacteria were used in different food products (as carriers), it was found that probiotics *Bacillus* They show higher survival than probiotic strains of *Bifidobacterium* and *Lactobacillus* regardless of the food ingredient studied, and the survival rate of the

strains *Bacillus* In vitro, the gastrointestinal tract was always above 83% [26]. As a spore-forming probiotic bacterium, *Bacillus coagulans* It is very important due to its high tolerance to harsh environmental conditions and probiotic properties. Firstly, *Bacillus coagulans* It can help improve intestinal digestion. Secondly, *Bacillus coagulans* It can regulate the host's symbiotic microbiota and prevent the growth of pathogenic bacteria. Finally, due to its ability to normalize quantitative parameters of the immune system and the functional activity of immune cells, *Bacillus coagulans* can be significantly beneficial to the host immune system [10]. In general, the survival rate of the strain *Bacillus Coagulans FC* Relative to *Bacillus Coagulans BC99* Both at the beginning of the study and after 12 months, the survival was lower, but this difference was not significant. After certain time intervals, in both directions *Bacillus* A slight decrease was observed at months 3, 6, and 12, but no significant difference ($p > 0.05$) These findings showed that grape pomace-based jam using natural sweetener (grape juice) could be an important food not only for carrying species *Bacillus* throughout their useful life, but could potentially ensure their survival in the conditions of the digestive tract.

Table 3. The stability of *B. Coagulans* of different fruit fillings during storage in the gastrointestinal tract (%)

Treatments	Day 0	Month 3	Month 6	Month 12
BC99	97.56 ±1.45 ^{Aa}	96.37 ±1.11 ^{Not}	95.78 ±0.98 ^{That}	95.34 ± 1.01 ^{And}
FC	97.01 ±1.23 ^{Ab}	95.98 ±1.13 ^{Bb}	94.86 ±1.36 ^{Cb}	94.79 ± 1.17 ^{Db}

Different lower- and upper-letter indicate statistically significant differences ($p < 0.05$) between samples at the same time and the same sample at various times.

3-1-2-Detect the presence of probiotic bacteria

Confocal laser scanning microscope images at the beginning and end of the brain preservation period-The jams in flour pastries are shown in Figure 1. Green dots correspond to live bacteria

and red dots correspond to dead bacteria. As can be seen, in both types of probiotic bacteria used, the number of green dots is higher on day zero and after 12 months of storage, the number of red dots has increased, indicating the viability of probiotic bacteria. Strain viability *Bacillus*

Coagulans BC99. It was more over time. Rubel et al. (2010) presented similar results to the present study and showed that over time the viability of

probiotic bacteria decreases and the number of red dots increases [27].

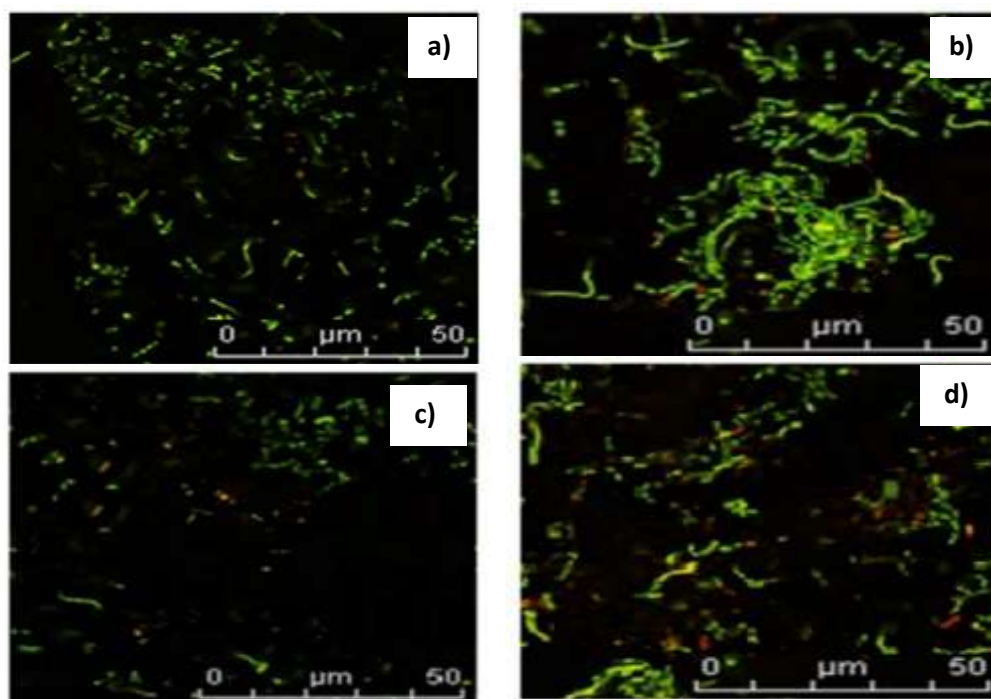


Fig. 1. Confocal laser microscopy of fruit fillings in biscuits. a) FC and b) BC99 at day 0, c) FC and d) BC99 at month 12.

3-1-2-Sensory evaluation

The results of the sensory evaluation of the jam kernels produced are shown in Figure 2. The overall acceptance was higher for kernels containing grape juice (i.e. functional jam kernels). However, there was a difference between the overall acceptance of functional kernels containing *Bacillus Coagulans* BC99 and *Bacillus Coagulans* FC. Statistically significant difference ($p < 0.05$) was not present, which indicates that the presence of probiotic strains does not affect product acceptance and the reason for the greater preference of evaluators for functional jam cores was the presence of grape juice in them instead of fructose syrup. It is likely that the greater desirability of taste and smell in functional jam cores led to an increase in their overall acceptance. However, the color of the control sample received more points and desirability than the functional cores. According

to the results of statistical analysis between the samples, there was no significant difference between the samples in terms of color, taste and smell, texture and overall acceptance during storage, which indicates the stability of the characteristics of the formulated jam cores during storage. In a study, according to the report of Kahraman et al. (2023), the addition of probiotic bacteria of different strains *Bacillus* Significant effect ($p > 0.05$) had no effect on overall acceptance and other sensory evaluation indices of the candy [18]. Afionizadeh and Goli (2022) used stevioside-isomalt, whey protein concentrate along with *Bacillus coagulans* bacteria in the muscat formulation. The results showed that the aforementioned compounds had no effect on the taste, but other organoleptic characteristics of the produced probiotic muscat samples were significantly changed [28].

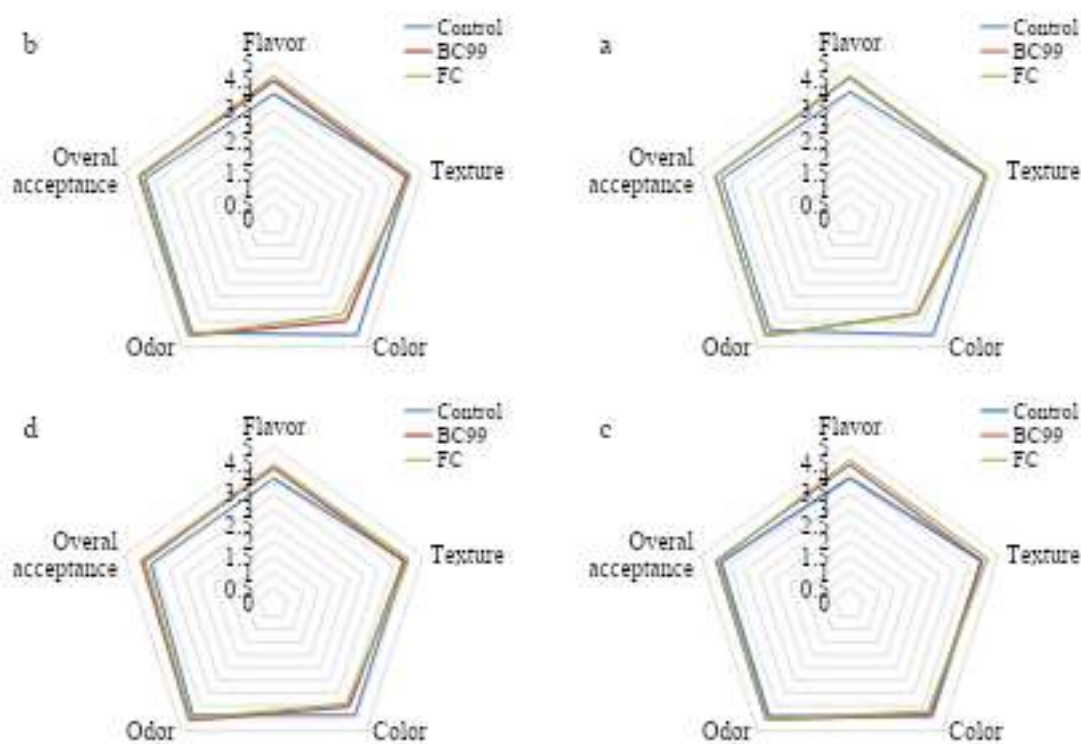


Fig. 3. Sensory properties of flour pastry samples during 12-month storage. a) day 0, b) month 3, c) month 6, and d) month 12.

4-Conclusion

In this study, a functional jam core containing two strains of the probiotic bacterium *Bacillus coagulans* was produced. Different amounts of grape pomace (2.5, 0.5, 7.5, and 10 grams) were used as a substitute for pectin and grape juice as a natural sweetener. Then, this core was used in the production of flour confectionery. The results showed that the survival percentage of both strains in the jam cores under conditions The gastrointestinal tract bioavailability is above 90%, confirming that jam kernels can be useful for transporting *Bacillus* species. Therefore, considering that in terms of sensory evaluation, the overall acceptance of kernels containing grape juice and *Bacillus coagulans* is higher than that of regular kernels, the use of grape juice (20.785%), HFCS (421.11 percent) And sorbitol syrup (99.5%) is recommended as a functional product for preparing jam fillings.

Conflict of interest

There are no items to declare.

Financial statement

This research has not received any specific financial support from government, commercial, or non-profit institutions.

Authors' Contributions

All authors contributed to the design, writing, and approval of the final version.

Artificial Intelligence Statement

Artificial intelligence was not used in the preparation and writing of this study.

5-Resources

- [1] Teslić, N., Kojić, J., Đermanović, B., Šarić, L., Maravić, N., Pestorić, M., & Šarić, B. (2023). Sour Cherry Pomace Valorization as a Bakery Fruit Filling: Chemical Composition, Bioactivity, Quality and Sensory Properties. *Antioxidants*, 12, (6), 1234.
- [2] Alam, M., Pant, K., Brar, D. S., Dar, B. N., & Nanda, V. (2024). Exploring the versatility of diverse hydrocolloids to transform techno-functional, rheological, and nutritional attributes of food fillings. *Food Hydrocolloids*, 146, 109275.
- [3] Ilyas, T., Chowdhary, P., Chaurasia, D., Gnansounou, E., Pandey, A., & Chaturvedi, P. (2021). Sustainable green processing of grape pomace for the production of value-added products: An overview. *Environmental Technology & Innovation*, 23, 101592.
- [4] Caponio, G. R., Minervini, F., Tamma, G., Gambacorta, G., & De Angelis, M. (2023). Promising application of grape pomace and its agri-food valorization: source of bioactive molecules with beneficial effects. *Sustainability*, 15(11), 9075.

- [5] Singh, P., Ban, Y., Kashyap, L., Siraree, A., & Singh, J. (2020). Sugar and sugar substitutes: recent developments and future prospects. *sugar derivatives: changing consumer preferences*, 39-75.
- [6] Balthazar, C. F., Guimarães, J. F., Coutinho, N. M., Pimentel, T. C., Ranadheera, C. S., Santillo, A., Sant'Ana, A. S. (2022). The future of functional food: Emerging technologies application on prebiotics, probiotics and postbiotics. *Comprehensive Reviews in Food Science and Food Safety*, 21(3), 2560-2586.
- [7] Zhou, D.-D., Li, J., Xiong, R.-G., Saimaiti, A., Huang, S.-Y., Wu, S.-X., Gan, R.-Y. (2022). Bioactive compounds, health benefits and food applications of grape. *Foods*, 11(18), 2755.
- [8] Anghel L, Milea AŞ, Constantin OE, Barbu V, Chişescu C, Enachi E, et al. Dried grape pomace with lactic acid bacteria as a potential source for probiotic and antidiabetic value-added powders. *Food Chemistry: X*. 2023;19:100777.
- [9] Sinrod AJ, Shah IM, Surek E, Barile D. Uncovering the promising role of grape pomace as a modulator of the gut microbiome: An in-depth review. *Heliyon*. 2023.
- [10] Cao J, Yu Z, Liu W, Zhao J, Zhang H, Zhai Q, et al. Probiotic characteristics of *Bacillus* coagulans and associated implications for human health and diseases. *Journal of Functional Foods*. 2020;64:103643.
- [11] Nikkam, I. T., Deshpande, H., Machewad, G., & Suryawanshi, H. (2023). Impact of fructooligosaccharide supplementation on generation time and viable count of *Bacillus* coagulans IS2 in green tea and black tea infusion. *The pharma journal*. 18(6), 1-9.
- [12] Polo, A., Cappello, C., Carafa, I., Da Ros, A., Baccilieri, F., Di Cagno, R., & Gobbetti, M. (2022). A novel functional herbal tea containing probiotic *Bacillus* coagulans GanedenBC30: An in vitro study using the Simulator of the Human Intestinal Microbial Ecosystem (SHIME). *Journal of Functional Foods*, 88, 104873.
- [13] Muñoz Pabon, K. S., Hoyos Concha, J. L., & Solanilla Duque, J. F. (2022). Quinoa extruded snacks with probiotics: Physicochemical and sensory properties. *Frontiers in Sustainable Food Systems*, 6, 935425.
- [14] Konuray, G., & Erginkaya, Z. (2020). Quality evaluation of probiotic pasta produced with *Bacillus* coagulans GBI-30. *Innovative Food Science & Emerging Technologies*, 6 (6), 102489.
- [15] Sekhavatizadeh, S. S., Aminlari, M., Gheisari, H. R., Shekarforoush, S. S., & Golmakani, M. T. (2019). Physicochemical and microbiological properties of probiotic kashk containing *Bacillus* coagulans. *Journal of Consumer Protection and Food Safety*, 14, 377-387.
- [16] Carcelli, A., Albertini, A., Vittadini, E., & Carini, E. (2022). A fibre syrup for the sugar reduction in fruit filling for bakery application. *International Journal of Gastronomy and Food Science*, 28, 100545.
- [17] Saber, F., Karami, M., Shiri, A., Rasouli, M., Karimi, R., & Kieliszek, M. (2024). Using grape pomace powder as a pectin replacer to prepare low water activity bake-stable fruit filling. *Journal of Food Measurement and Characterization*. 18, 4314-4322.
- [18] Kahraman, B., Korkmaz, K., Daştan, D., Toker, O. S., Dertli, E., & Arici, M. (2023). Production and characterization of probiotic jelly candy containing *Bacillus* species. *Journal of Food Measurement and Characterization*, 17(6), 5864-5873.
- [19] Buriti, F. C. A., Castro, I. A., & Saad, S. M. I. (2010). Viability of *Lactobacillus acidophilus* in synbiotic guava mousses and its survival under in vitro simulated gastrointestinal conditions. *International Journal of Food Microbiology*, 137(2), 121-129.
- [20] Fijan, S., Fijan, T., & Connil, N. (2023). Overview of probiotic strains of *Weizmannia* coagulans, previously known as *Bacillus* coagulans, as food supplements and their use in human health. *Applied Microbiology*, 3(3), 935-947.
- [21] Dolati, M., Tafvizi, F., Salehipour, M., Komeili Movahed, T., & Jafari, P. (2023). Biogenic copper oxide nanoparticles from *Bacillus* coagulans induced reactive oxygen species generation and apoptotic and anti-metastatic activities in breast cancer cells. *Scientific Reports*, 13(1), 3256.
- [22] da Costa Cardoso PIF, Grisi CVB, de Andrade Vieira É, de Almeida DKL, Cardarelli HR. Cereal flours with *Bacillus* coagulans and beta-glucan: Technological properties and sensory acceptability. *Food Chemistry*. 2024;448:139146.
- [23] Gbassi, G. K., Vandamme, T., Yolou, F. S., & Marchioni, E. (2011). In vitro effects of pH, bile salts and enzymes on the release and viability of encapsulated *Lactobacillus plantarum* strains in a gastrointestinal tract model. *International Dairy Journal*, 21(2), 97-102.
- [24] Razavi, R., Kenari, R. E., Farmani, J., & Jahanshahi, M. (2020). Fabrication of zein/alginate delivery system for nanofood model based on pumpkin. *International Journal of Biological Macromolecules*, 165, 3123-3134.
- [25] Schillinger, U., Guigas, C., & Heinrich Holzapfel, W. (2005). In vitro adherence and other properties of lactobacilli used in probiotic yoghurt-like products. *International Dairy Journal*, 15(12), 1289-1297.
- [26] Soares, M. B., Martinez, R. C. R., Pereira, E. P. R., Balthazar, C. F., Cruz, A. G., Ranadheera, C. S., & Sant'Ana, A. S. (2019). The resistance of *Bacillus*, *Bifidobacterium*, and *Lactobacillus*

- strains with claimed probiotic properties in different food matrices exposed to simulated gastrointestinal tract conditions. *Food Research International*, 125, 108542.
- [27] Röble, C., Auty, M. A. E., Brunton, N., Gormley, R. T., & Butler, F. (2010). Evaluation of fresh-cut apple slices enriched with probiotic bacteria. *Innovative Food Science & Emerging Technologies*, 11(1), 203-209.
- [28] Afyounizadeh Esfahani, D. and M. Goli. (2022). The effect of Stevioside-Isomalt, whey protein concentrate, and Bacillus coagulans on the physicochemical and sensory properties of Iranian probiotic Masghati sweet. *Journal of Food Processing and Preservation*. 46(10): p. e16028.



بررسی تاثیر استفاده از پودر تفاله انگور برای تولید مغزی‌های مربایی فراسودمند دارای باسیلوس

کواگولانس بر ویژگی‌های فیزیکوشیمیایی و حسی شیرینی آردی

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