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DEVELOPMENT AND EVALUATION OF LOW-CALORIE STRAWBERRY JAM ENRICHED WITH PSYLLIUM HUSK: A FUNCTIONAL INGREDIENT APPROACH

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KEYWORDS:

healthy jam, low sugar, dietary fibers, health promotion, food formulation

ABSTRACT

This study aimed to develop a nutritionally enhanced strawberry jam by partially replacing sugar with psyllium husk, a functional dietary fiber known for its water-binding and gel-forming capabilities. Three reduced-sugar formulations (Trials 1–3) containing 25 % psyllium husk solution and varying sugar concentrations (12 %, 26 %, and 30 %) were compared to a traditional control jam (66 % Brix). The impact of psyllium inclusion on the physical, chemical, microbiological, and sensory properties of the jams was evaluated. Sensory analysis was performed by a trained panel of 20 consumers using a 9-point hedonic scale to assess appearance, flavor, odor, spreadability, and overall acceptability. Results showed that psyllium-enriched formulations had significantly lower Brix, total carbohydrates, ash content, and estimated caloric values, while fiber content increased up to 1.05 g/100 g. The pH of all samples remained below 3.0, ensuring microbial safety, with total plate counts <1.0 log CFU/g across all treatments. Instrumental color analysis indicated improved lightness and redness in fiber-enriched samples. Among the tested samples, Trial 3 (30 % sugar, 25 % psyllium husk solution) achieved the highest sensory scores and reached a final Brix value of 63 %, making it the most acceptable formulation. These findings demonstrate that psyllium husk can successfully replace part of sugar while enhancing nutritional value, texture, and palatability. The optimized formulation shows promising potential for commercial application in producing healthier, low-calorie fruit preserves.

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Научная статья

Открытый доступ

РАЗРАБОТКА И ОЦЕНКА НИЗКОКАЛОРИЙНОГО КЛУБНИЧНОГО ДЖЕМА, ОБОГАЩЕННОГО ШЕЛУХОЙ СЕМЯН ПОДРОЖНИКА: ПОДХОД С ИСПОЛЬЗОВАНИЕМ ФУНКЦИОНАЛЬНЫХ ИНГРЕДИЕНТОВ

Баюми А. А., Абдельдайем Ф. А., Абдельфаттах Т. Т., Азиз М. М., Хамед Р. Р., Юсеф Ю. Х., Абдельмаксуд Т. Г.*

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КЛЮЧЕВЫЕ СЛОВА: АННОТАЦИЯ

полезный для здоровья джем, низкое содержание сахара, стимулирование здоровья, рецептура пищевого продукта

Целью данного исследования была разработка обогащенного нутриентами клубничного джема с частичной заменой сахара на шелуху семян подорожника — функциональных пищевых волокон, известных своими водосвязывающими и гелеобразующими свойствами. Проведено сравнение трех рецептур с пониженным содержанием сахара (опыты 1–3), содержащих 25 % раствора шелухи семян подорожника и различные концентрации сахара (12 %, 26 %, и 30 %) и традиционного контрольного джема (66 % Брикс). Оценивали влияние включения подорожника на физические, химические, микробиологические и органолептические свойства джемов. Органолептический анализ был проведен обученной дегустационной комиссией из 20 потребителей, используя девятибалльную гедонистическую шкалу для оценки внешнего вида, флейвора, запаха, способности к намазыванию и общей приемлемости. Результаты показали, что обогащенные подорожником рецептуры имеют значимо более низкие уровни Брикс, общих углеводов, содержания золы и оцененные уровни калорий, в то время как содержание клетчатки увеличилось до 1,05 г/100 г. Уровни pH всех образцов оставались ниже 3,0, обеспечивая микробиологическую безопасность с общим количеством микроорганизмов, определенным чашечным методом, <1,0 log КОЕ/г во всех обработках. Инструментальный анализ цвета показал улучшенную светлоту и красноту в обогащенных волокнами образцах. Среди протестированных образцов, опыт 3 (30 % сахара, 25 % раствора шелухи семян подорожника) получил наивысшие баллы органолептической оценки и достиг конечного уровня Брикс 63 %, что делает его наиболее приемлемой рецептурой. Эти результаты демонстрируют, что шелуха семян подорожника может успешно заменить часть сахара при повышении питательной ценности, текстуры и вкусовых качеств. Оптимизированная рецептура обладает потенциалом для коммерческого применения при производстве более полезных, низкокалорийных фруктовых консервов.

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1. Introduction

Strawberries (*Fragaria x ananassa*), members of the Rosaceae family, are among the most widely consumed berries worldwide and are extensively used in the production of jams, ice creams, and juices due to their appealing flavor, vivid red color, and nutritional richness. Strawberry cultivation is highly adaptable to diverse climates and is characterized by high yield potential. Egypt ranks among the top 15 global strawberry exporters and is the leading producer in Africa, with production reaching approximately 638,000 tons in 2022, showing robust annual growth in both cultivated area and yield. The continuous development of Egypt's strawberry sector has been driven by technological improvements and increasing global demand, consolidating the country's position as a major player in international strawberry markets [1–4]. Strawberries consist primarily of water (91%) and carbohydrates (7.7%), and are rich in vitamins, polyphenols, and dietary fiber [5]. Their bioactive components contribute to various health benefits, including antioxidant activity, anti-inflammatory effects, improved vascular function, and reduced LDL oxidation — factors linked to the prevention of chronic diseases such as cardiovascular disorders and certain cancers. Numerous studies have shown that phenolic compounds, anthocyanins, and vitamin C in strawberries play a significant role in the reduction of oxidative stress, amelioration of lipid profiles, inhibition of inflammatory pathways, and protection against the proliferation of cancer cells [6,7]. However, due to their high perishability, strawberries are often processed into shelf-stable products such as jams to reduce postharvest losses while preserving their nutritional value. Strawberries spoil rapidly after harvest because of their delicate skin, high respiration rate, and susceptibility to microbial contamination, so processing into jams and similar products is a well-established strategy to extend usability and minimize waste without significantly compromising key nutrients [8,9].

Jam is a widely consumed fruit preserve prepared by heating fruit pulp with sugar, pectin, and acid to create a stable gel matrix. Conventional jams typically contain high levels of added sugars, commonly reaching up to 65% Brix, which serve crucial roles in ensuring microbial stability, gel structure, and overall palatability. Despite their favorable sensory attributes, these elevated sugar contents have raised health concerns due to their association with an increased risk of noncommunicable diseases (NCDs) such as obesity, type 2 diabetes, and cardiovascular disorders. The growing awareness of these health risks is driving demand for fruit preserves with reduced sugar content and enhanced nutritional value [10].

According to the World Health Organization (WHO), global per capita sugar consumption exceeds 50–100 grams per day in many countries, which is about twice the recommended limit of less than 10% of total daily energy intake. Reducing free sugar intake to below 5% of total daily energy intake, roughly 25 grams (6 teaspoons) per day for adults offers additional health benefits, such as lowering risks of overweight, obesity, tooth decay, and noncommunicable diseases. These recommendations are supported as a long-term public health goal by both WHO and FAO, and have been jointly reiterated in their latest nutrition guidelines and action plans. High sugar consumption is strongly associated with obesity, type 2 diabetes, metabolic syndrome, dental caries, and cardiovascular disease. These alarming trends have led consumers and industry stakeholders to seek healthier alternatives that reduce sugar without compromising product quality [11–14].

In response, the incorporation of dietary fibers into food formulations has gained increasing attention. Fiber intake is essential for digestive health, glycemic control, and satiety, yet global intake remains below recommended levels, 21–25 g/day for women and 30–40 g/day for men. Among functional fibers, psyllium husk (derived from *Plantago ovata*) stands out due to its unique composition (approximately 35% soluble and 65% insoluble fiber) and exceptional water absorption capacity [15,16]. Its gelling, emulsifying, and stabilizing properties make it an ideal clean-label ingredient in low-calorie food products [17].

Psyllium husk is widely recognized for its ability to improve the texture and increase the dietary fiber content in both bakery and extruded products. Its safety has been affirmed by the FDA, and its use in food is well established, particularly for supporting cardiovascular and digestive health. Additionally, psyllium husk maintains excellent stability under heat and varying pH levels, making it a suitable ingredient in jam processing and other thermal applications [18,19].

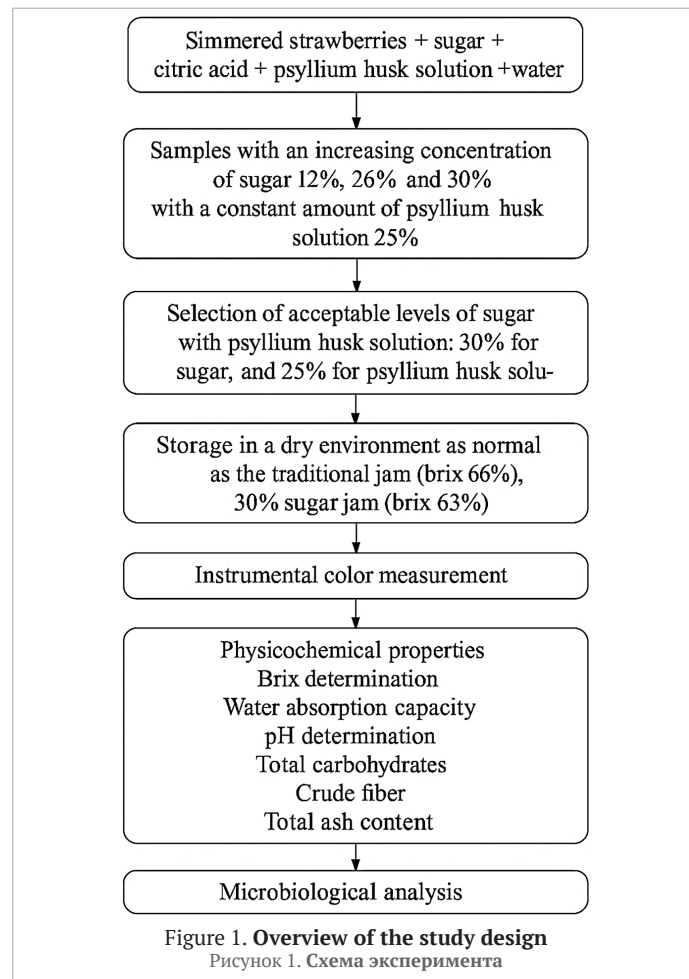
This study aims to develop a healthier, lower-calorie strawberry jam by partially replacing added sugar with a 25% psyllium husk solution. The optimized formulation specifically targets a significantly reduced sugar content (30% versus the conventional 60–65%) while maintaining critical quality attributes — including total soluble solids (Brix), pH, textural integrity, and desirable sensory attributes. By incorporating psyllium

husk as a source of functional soluble fiber, the research seeks to enhance the nutritional value of the jam, promoting potential physiological benefits associated with increased dietary fiber intake. The overarching objective is to produce a functional fruit preserve that combines improved healthfulness and consumer acceptability, thereby fulfilling the expanding market demand for clean-label, fiber-enriched, and nutritionally superior fruit-based products.

2. Objects and methods

2.1. Ingredients used in jam preparation

Strawberries (*Fragaria x ananassa*) were selected as the primary fruit due to their balanced pectin and sugar content, which support proper gel formation. Fresh strawberries, stored at 4 °C prior to processing, enabled a 1:1 fruit-to-sugar ratio, contributing to the desirable consistency and typical physicochemical profile of strawberry jam (60–65% TSS, pH ~3.3). The final product was stored at 20 °C for shelf stability. Sugar (high-purity, bright white) served multiple functions, including sweetness, gel formation, and microbial stability. The traditional jam formulation (as a control sample) relies on high sugar concentrations (60–65% Brix). However, to reduce caloric content, this study decreased sugar levels by 45%. Despite the reduction, sugar's role in achieving proper Brix values and sensory quality was maintained by combining it with psyllium husk as a natural gelling agent. Citric acid was incorporated at 2 g/kg of added sugar, following established formulations [20], and added at the final stage of cooking to prevent sugar crystallization and enhance gel structure. Its inclusion improved flavor, microbial safety, and pH balance, supporting effective gel formation [21]. Psyllium husk (*Plantago ovata*), obtained from local suppliers in Egypt (e. g., Pyramids Herbs, Herbs Oasis, El Badr for Import and Export, Nile Herbal), was used as a clean-label gelling agent. Containing approximately 87.3% dietary fiber and known for its high-water absorption capacity (absorbing up to 45 times its weight), psyllium husk provides a gel-like texture while supporting satiety and health benefits [22,23]. A 25:1 water-to-husk ratio was used to hydrate the psyllium, which was then incorporated into the jam mixture to compensate for the reduced sugar and maintain traditional jam texture and consumer acceptability. An overview of the study design is shown in Figure 1.



2.2. Jam preparation

Fresh, high-quality strawberries (*Fragaria x ananassa*), locally known as ‘Baladi Strawberries’, were selected, washed thoroughly, decrowned, and cut into small pieces. The fruit was blended with sugar (55% of the total mixture weight) and simmered with continuous stirring to promote pectin release. Citric acid was added to improve texture and prevent crystallization. Psyllium husk quality was assessed via sensory evaluation and water absorption testing to confirm its gelling capacity. A psyllium gel was prepared using 25 mL of warm water per gram of husk, and 45% of this solution (relative to the sugar content typically used) was incorporated into the jam formulation. The mixture was boiled until the total soluble solids (TSS) reached 63% Brix at 20 °C. The psyllium solution was then combined with the cooked strawberry blend, and the jam was rapidly concentrated. Foam was removed, and citric acid was added as a preservative. The final product was hot-filled into sterilized jars at 104 °C, inverted to sanitize the lids and create a vacuum seal, then cooled to 4 °C. Samples were stored in a dry environment and subjected to physicochemical, microbiological, and sensory evaluations. The following table shows the formulations of the control and trials (Table 1).

Table 1. Control and trials of strawberry jam enriched with psyllium husk)

Таблица 1. Контрольные образцы и опытные образцы клубничного джема, обогащенного шелухой семян подорожника

Samples	Components (%)			
	Strawberry	Sugar	Water added	Psyllium husk solution
Control	45	55	0	0
Trial 1	45	12	18	25
Trial 2	45	26	4	25
Trial 3	45	30	0	25

2.3. Physical and chemical analysis

2.3.1. Brix determination

The Brix percentage (%), representing the concentration of total soluble solids (TSS) in an aqueous solution, serves as a key indicator of jam sweetness and overall quality. In this study, various sugar concentrations (12%, 26%, and 30%) were evaluated to identify the optimal Brix value for low-sugar jam formulations, while maintaining the psyllium husk solution at a constant 25% concentration. Brix values were measured using a handheld ATC refractometer (ATAGO CO., LTD., Japan) at 20 °C. A small aliquot of each jam sample was deposited onto the prism surface of the refractometer, the cover was gently closed to distribute the sample evenly, and the device was held perpendicular to a light source. The Brix reading was obtained by observing the demarcation line on the internal scale. This procedure enabled precise quantification of TSS, thereby facilitating the selection of the optimal sugar content for health-oriented jam formulations.

2.3.2. Water absorption capacity

The water absorption capacity (WAC) of psyllium husk is a fundamental property that contributes to its bulking effect and gelling ability. Psyllium husk is known to absorb approximately 45 mL of water per gram. The WAC was assessed following the method reported by Chen et al. [16], wherein 1 g of psyllium husk was combined with 10 mL of distilled water under continuous stirring until saturation. The additional volume of water required to fully hydrate the husk was recorded, providing an empirical measure of its absorption capacity. Figure 2 illustrates the psyllium husk solution.

2.3.3. Color measurement

Color is a critical sensory attribute that directly influences consumer acceptance. The color stability of jams can be affected by factors such as pH, exposure to light and oxygen, thermal processing, enzymatic browning, and sugar degradation [24]. The color of the psyllium husk-enriched jam was analyzed using a colorimeter CHROMA METER CR-410 (Konica



Minolta). Prior to measurement, the instrument was calibrated using standard white and black tiles. Color was assessed using the CIE Lab* system: L* denotes lightness (0 = black, 100 = white), a* indicates red-green chromaticity (positive = red, negative = green), and b* represents yellow-blue chromaticity (positive = yellow, negative = blue). This analytical protocol ensured reproducible and objective color evaluations.

2.3.4. pH determination

Pectin gelation in fruit-based jams is pH-dependent, with an optimal range of 2.8–3.5, as defined by the CODEX Standard for Jams (Fruit Preserves) and Jellies [25]. The pH of the strawberry jam formulations was determined using a calibrated Jenway Model 3305 pH meter (Jenway, UK). For each measurement, 1 g of the jam sample was diluted in 10 mL of distilled water and gently homogenized. The probe was immersed in the solution at ambient temperature (25–26 °C), and pH values were recorded after stabilization.

2.3.5. Total carbohydrates

Total carbohydrate content, reflecting the concentration of mono- and disaccharides such as glucose, fructose, and sucrose, was quantified using the phenol-sulfuric acid colorimetric method developed by Dubois et al. [26]. A 100 µL aliquot of each extract was mixed with 1 mL of 5% phenol solution and 5 mL of concentrated sulfuric acid. The reaction mixture was allowed to cool to room temperature, and absorbance was measured at 490 nm using a UV-Vis spectrophotometer Jenway 6715 (Jenway, UK). D-glucose was used as a standard for calibration, and results were calculated using the regression equation $Y = 92.804x + 0.6703$ ($R^2 = 0.995$), expressed as grams per 100 grams of sample.

2.3.6. Crude fiber

Crude fiber, a non-digestible component beneficial for gut health and microbial fermentation, was measured using the Weende method AOAC [27]. The procedure involved sequential acid (1.25% H₂SO₄) and alkaline (1.25% NaOH) hydrolysis to eliminate digestible carbohydrates. The remaining residue was incinerated at high temperature in a muffle furnace Vulcan A-550 (Degussa-ney dental Inc., USA), followed by drying in a convection oven Binder FD53 (Binder, Germany). The resulting ash-free residue represented the crude fiber content.

2.3.7. Ash content

Ash content, representing the total mineral residue remaining after complete combustion of organic matter, was determined using the standard AOAC method [27]. Samples were subjected to dry ashing in a muffle furnace Vulcan A-550 (Degussa-ney dental Inc., USA) at 500–600 °C. The organic matter was incinerated in the presence of oxygen, resulting in the release of CO₂ and N₂, along with volatilization of water and organics. The residual ash was weighed using an analytical balance Shimadzu ATY Series (Shimadzu, Japan) and expressed as a percentage of the original sample mass.

2.4. Microbiological analysis

The Total Plate Count (TPC) method was used to quantify microbial load, including bacteria, yeast, and mold, as an indicator of product safety and hygiene. The analysis employed the pour plate technique using Plate Count Agar (PCA). Serial dilutions (5–10-fold) of each sample were prepared in sterile saline. A 1 mL aliquot from each dilution was aseptically transferred to a sterile Petri dish, followed by the addition of 15–20 mL of molten PCA. Plates were incubated in an incubator Memmert IN30 (Mettler GmbH, Germany) in an inverted position at 30 °C for 24–48 hours. Colony-forming units (CFUs) were enumerated post-incubation. The microbiological assessments were conducted under controlled conditions (ambient temperature 22.5 °C; relative humidity 42.1 %) [28].

2.5. Sensory evaluation

A structured sensory analysis was conducted to assess consumer perception and preference between the control (conventional jam) and the developed psyllium-enriched jam. A total of 20 trained panelists evaluated samples based on five attributes: appearance, flavor, aroma, spreadability, and overall acceptability. The evaluation employed a 9-point hedonic scale (1 = ‘dislike extremely’ to 9 = ‘like extremely’) [29]. Panelists were provided with individual plastic spoons and paper ballots for scoring, and a cup of water was supplied to cleanse their palates between samples. Notably, color perception was strongly influenced by the presence of anthocyanins, plant-based pigments responsible for the characteristic red hue of strawberries and known for their antioxidant and protective functions.

2.6. Statistical analysis

All quantitative data were statistically analyzed using one-way analysis of variance (ANOVA) to determine significant differences among

treatment groups. This method allowed for the comparison of mean values across the control and psyllium-enriched jam samples. Differences were considered statistically significant at $p < 0.05$. The ANOVA analysis provided a robust statistical basis for evaluating consumer acceptance scores, chemical composition, and microbiological data across multiple replicates [30].

3. Results and discussion

3.1. Physical and chemical properties of psyllium-enriched strawberry jam

The data presented in Table 2 highlight the significant impact of reducing sugar and incorporating psyllium husk on the physical characteristics of strawberry jam formulations (Figure 3). These changes reflect an effort to produce a healthier jam alternative with improved nutritional properties and acceptable quality attributes.

Table 2. Physical properties of the control and formulated strawberry psyllium jam

Таблица 2. Физические свойства контрольного клубничного джема и клубничного джема с подорожником

Parameters	Control	Trial 1	Trial 2	Trial 3
pH	2.82 ± 0.01 ^d	2.91 ± 0.02 ^c	2.93 ± 0.03 ^b	2.98 ± 0.01 ^a
L*	26.51 ± 0.12 ^b	26.78 ± 0.16 ^b	26.85 ± 0.14 ^b	27.29 ± 0.18 ^a
a*	11.36 ± 0.10 ^b	11.72 ± 0.08 ^b	12.00 ± 0.10 ^{a^b}	12.43 ± 0.07 ^a
b*	1.20 ± 0.02 ^c	1.31 ± 0.03 ^b	1.35 ± 0.04 ^{a^b}	1.39 ± 0.03 ^a
ΔE	–	0.58	0.88	1.20

Note: All values are expressed as mean ± SD ($n = 3$). ΔE was calculated using the control as a reference. Water absorption measured only for psyllium husk. Control (traditional jam): 45 % strawberry, 55 % sugar.

Trial 1: 45 % strawberry, 12 % sugar, 18 % added water, 25 % psyllium husk solution.

Trial 2: 45 % strawberry, 26 % sugar, 4 % added water, 25 % psyllium husk solution.

Trial 3: 45 % strawberry, 30 % sugar, no added water, 25 % psyllium husk solution.

The pH values ranged from 2.82 (control) to 2.98 (Trial 3), indicating that lower sugar formulations preserved a slightly higher pH, likely due to dilution effects and the buffering capacity of fiber. The pH values remained within the acceptable range for jam preservation (<4.5), ensuring microbial safety and favorable gel formation [31]. Color is critical for consumer acceptance. All jam samples maintained vibrant red tones, with increasing a* values indicating intensified redness in fiber-rich jams. Trial 3 had the highest L* (27.29) and a* (12.43) values, possibly due to reduced caramelization at lower sugar levels and enhanced light scattering from fiber [32]. The calculated ΔE of 1.20 suggests perceptible but not dramatic differences in color compared to the control.

In terms of visual appeal, Trial 3 achieved the highest color rating (8.14 ± 0.11). This result aligns with the instrumental color data (Table 2), which indicated higher L* and a* values, denoting a brighter and redder product, as illustrated in Figure 3. The absence of added water likely helped maintain the color intensity, as dilution can often lead to paler, less appealing hues. The natural color retention of strawberries, complemented by the fiber matrix of psyllium, contributed to an overall vibrant product.

The data presented in Table 3 highlight the chemical and microbiological properties of control and formulated strawberry psyllium jam

The Brix value reflects total soluble solids, mainly sugars. The control jam, formulated traditionally with high sugar (approximately 66%), exhibited a Brix of 66%, consistent with CODEX standards for conventional jams [25]. Trial 3, incorporating 30% sugar and no added water, reached a Brix of 63%, validating its suitability for low-sugar jam development.

Table 3. Chemical and microbiological properties of the control and formulated strawberry psyllium jam

Таблица 3. Химические и микробиологические свойства контрольного клубничного джема и клубничного джема с подорожником

Parameters	Psyllium Husk	Control	Trial 1	Trial 2	Trial 3
Brix, %	–	66.00 ± 0.32 ^a	55.00 ± 0.41 ^d	57.00 ± 0.28 ^c	63.00 ± 0.37 ^b
Water absorption, ml/g	46.00 ± 0.24	–	–	–	–
Total carbohydrates, g/100 g	–	41.93 ± 0.44 ^a	38.75 ± 0.35 ^b	36.12 ± 0.38 ^c	33.65 ± 0.41 ^d
Crude fiber, g/100 g	–	0.65 ± 0.02 ^d	0.84 ± 0.01 ^c	0.92 ± 0.01 ^b	1.05 ± 0.01 ^a
Ash, %	–	0.49 ± 0.01 ^a	0.38 ± 0.01 ^b	0.32 ± 0.01 ^c	0.24 ± 0.01 ^d
Estimated calories, kcal/100g	–	166.42 ± 0.50 ^a	153.32 ± 0.45 ^b	142.64 ± 0.47 ^c	132.50 ± 0.48 ^d
Total Plate Count, log CFU/g	–	<1.00	<1.00	<1.00	<1.00

Note: All values are expressed as mean ± SD ($n = 3$).

Control (traditional jam): 45 % strawberry, 55 % sugar.

Trial 1: 45 % strawberry, 12 % sugar, 18 % added water, 25 % psyllium husk solution.

Trial 2: 45 % strawberry, 26 % sugar, 4 % added water, 25 % psyllium husk solution.

Trial 3: 45 % strawberry, 30 % sugar, no added water, 25 % psyllium husk solution.

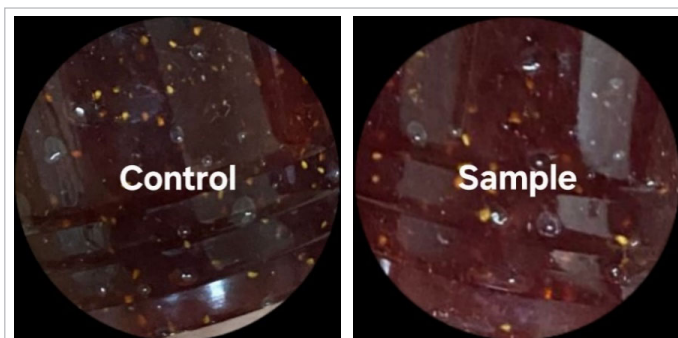


Figure 3. Control and modified sample (Trial 3)

Рисунок 3. Контрольный и модифицированный образец (опыт 3)

The stepwise increase in Brix from Trial 1 (55%) to Trial 3 (63%) demonstrates how sugar concentration governs soluble solids and gel formation.

Psyllium husk absorbed 46 ml of water/g, demonstrating its high hydration potential. This contributed to improved consistency, enhanced mouthfeel, and water retention in low-sugar formulations. Its high swelling index mimics sugar's bulking effect, critical for maintaining jam structure without synthetic additives [33].

The reduction of sugar content from 26% to 12% led to a progressive decline in total carbohydrates, from 41.93 g/100g in the control sample to 33.65 g/100g in Trial 3. Conversely, the crude fiber content increased to 1.05 g/100g in the final trial, attributed to the incorporation of psyllium husk. These findings are consistent with recent studies on fiber-enriched fruit jellies, which demonstrate that lowering sugar while supplementing with dietary fiber not only significantly reduces total carbohydrate content but also increases fiber levels compared to conventional formulations. Such modifications have been shown to create products better suited for health-conscious consumers seeking functional foods that support glycemic control and digestive health. The use of psyllium, in particular, is highlighted for its positive impact on both nutritional profile and physiological benefits, including improved glycemic response and gastrointestinal function [34,35].

Ash content, which reflects the total mineral residue, decreased from 0.49% in the control sample to 0.24% in Trial 3. Although ash content is not a direct indicator of nutritional superiority, its reduction in psyllium-rich formulations suggests fewer added salts and minerals, aligning well with current trends in clean-label product development. Similar trends have been reported by other authors, where ash content in fruit jams typically ranges from 0.20% to 0.34%, and lowering mineral additives is associated with a cleaner nutritional label and often perceived as more natural by consumers. Additionally, studies have shown that the ash concentration can decrease due to both the use of fewer added mineral ingredients and potential leaching losses during processing. These values are consistent with dietetic and functional jams developed using natural fiber sources, further supporting the results found in the present study [36,37].

All samples maintained low total plate counts (<1.0 log CFU/g), indicating excellent microbiological safety. Controlled processing steps such as heating and hygienic packaging, combined with pH values below 3.0 and the hygroscopic properties of psyllium, contributed to the shelf stability of the products. The microbial load remained well within established limits for commercial jams, validating the preservative efficacy of low pH and proper formulation practices. These results are consistent with other studies on fruit jams, which report total plate counts

below critical thresholds and emphasize the role of acidity, processing, and packaging in ensuring microbiological safety and extended shelf life. Therefore, the findings confirm that applying low pH and strict hygienic measures is effective for preserving jam quality and safety, in accordance with industry and regulatory standards [38,39]. The calculated energy values of the strawberry jam samples demonstrated a clear inverse relationship between sugar content and caloric value. The control sample, containing the highest total carbohydrates (41.93 g/100 g), exhibited the highest energy content at 166.42 kcal/100g. In contrast, Trial 3, formulated with reduced sugar and enriched with psyllium husk, had the lowest carbohydrate content (33.65 g/100g) and consequently the lowest caloric value at 132.50 kcal/100g. This caloric reduction aligns with the functional role of psyllium husk, which not only contributes dietary fiber but also enables sugar reduction without compromising texture. Comparable studies on reduced-calorie jams prepared with alternative bulking fibers and sweeteners, such as maltitol or apple pomace, report pronounced decreases in both carbohydrate and energy values, ranging from a typical jam value of 136–263 kcal/100 g and carbohydrate levels of 65–73 g/100 g, down to 96–156 kcal/100 g and carbohydrate contents as low as 22–33 g/100 g for fiber-enriched or sugar-reduced formulations. The incorporation of psyllium or similar dietary fibers thus effectively enhances the nutritional profile of jam, making it more suitable for health-conscious consumers and those aiming to follow low-calorie or diabetic-friendly diets [33,36,40–42].

3.2 Sensory evaluation

The sensory evaluation results presented in Table 4 reveal distinct consumer preferences and demonstrate the success of using psyllium husk as a functional ingredient in reduced-sugar strawberry jam formulations. All sensory attributes (taste, odor, color, spreadability, and overall acceptability) were evaluated on a 9-point hedonic scale, with Trial 3 emerging as the most favored formulation across the board.

Table 4. Sensory evaluation scores

Таблица 4. Баллы органолептической оценки

Parameter	Control	Trial 1	Trial 2	Trial 3
Taste	6.60±0.20 ^d	7.10±0.18 ^c	7.46±0.19 ^b	8.03±0.16 ^a
Odor	6.80±0.15 ^d	7.10±0.12 ^c	7.45±0.13 ^b	7.86±0.12 ^a
Color	7.42±0.14 ^d	7.58±0.15 ^c	7.85±0.14 ^b	8.14±0.11 ^a
Spreadability	5.60±0.20 ^d	6.12±0.18 ^c	6.78±0.17 ^b	7.40±0.15 ^a
Overall Acceptability	6.93±0.22 ^d	7.31±0.20 ^c	7.76±0.21 ^b	8.15±0.17 ^a

Note: All values are expressed as mean ± SD (n = 3).

Control (traditional jam): 45% strawberry, 55% sugar

Trial 1: 45% strawberry, 12% sugar, 18% added water, 25% psyllium husk solution.

Trial 2: 45% strawberry, 26% sugar, 4% added water, 25% psyllium husk solution.

Trial 3: 45% strawberry, 30% sugar, no added water, 25% psyllium husk solution.

Taste scores were highest in Trial 3 (8.03±0.16), which contained 30% sugar and no added water, indicating that consumers appreciated the sweet intensity balanced by the natural tartness of the strawberries and the gel-forming properties of psyllium. The sugar level, although reduced compared to traditional jams, provided adequate sweetness without overpowering the natural fruit flavor. This demonstrates that psyllium husk

can effectively contribute to mouthfeel and gel structure, allowing for reduced sugar usage without sacrificing palatability.

Odor was also highly rated in Trial 3 (7.86±0.12), suggesting that the formulation preserved volatile aromatic compounds well. The limited water content in this trial likely contributed to the concentration and retention of fruit aroma, which plays a key role in consumer satisfaction [26].

Spreadability is a fundamental functional attribute that significantly influences jam quality and consumer acceptance. In our study, Trial 3 exhibited a notable improvement in spreadability (7.40±0.15) compared to the control (5.60±0.20). This enhancement is primarily attributed to the high water absorption and gel-forming capabilities of psyllium husk, which provided the jam with a smooth, cohesive texture without the use of artificial thickeners or pectin, thereby promoting ease of application on bread and pastries and facilitating consumer convenience. These results closely align with previously published research, where spreadability values for jams ranged from 5.8 to 7.0, and the incorporation of natural fibers or alternative thickeners, such as psyllium husk or xanthan gum, consistently led to noticeable improvements in spreadability relative to conventional pectin-based jams. For instance, pineapple-carrot and black plum peel jams fortified with dietary fibers achieved elevated spreadability scores, reaching up to 7.0±0.2 and 6.9±0.4, respectively, highlighting the positive impact of natural hydrocolloids on texture and consumer experience [43–45]. Collectively, the evidence demonstrates that psyllium husk represents a highly effective natural option for enhancing the spreadability and texture of jam. This approach results in superior functional and sensory qualities compared to traditional formulations, while maintaining desirable taste and user-friendliness attributes that contribute positively to consumer satisfaction and product competitiveness.

Overall acceptability, the most integrative parameter, reached its peak in Trial 3 (8.15±0.17), reflecting high consumer satisfaction across all sensory dimensions. These results validate the potential of psyllium husk as a multifunctional dietary fiber that enhances both the health value and the sensory properties of fruit preserves.

In summary, Trial 3 successfully combined reduced sugar content with enhanced sensory quality, making it a promising candidate for health-conscious consumers seeking lower-calorie, high-fiber fruit spreads without compromising taste, texture, or appearance. Its strong performance in the sensory evaluation supports its marketability as a nutritionally improved alternative to traditional jams.

4. Conclusion

In conclusion, incorporating psyllium husk into strawberry jam formulations effectively enhances nutritional quality by increasing dietary fiber and reducing sugar content without compromising sensory attributes. Trial 3, with 30% sugar and psyllium addition, demonstrated superior taste, color, spreadability, and overall acceptability, meeting consumer preferences for healthier, low-calorie options. Physicochemical analysis confirmed acceptable pH, color stability, and microbial safety, supporting product shelf-life and quality. This study highlights psyllium husk's potential as a natural functional ingredient to develop fiber-enriched, reduced-sugar fruit spreads, offering a promising alternative for health-conscious consumers seeking nutritious and enjoyable jam products. Future studies are recommended to investigate the shelf life under accelerated storage conditions and evaluate consumer acceptance at a commercial scale.

БИБЛИОГРАФИЧЕСКИЙ СПИСОК / REFERENCES

- Shojaee, F. M., Kazemi, E. M., Nosrati, H., Kolahi, M., Haghi, M. (2023). Evaluation of phytochemicals and the role of oxidative stress pathways during fruit development in strawberries (*Fragaria × ananassa*). *Turkish Journal of Botany*, 47(5), 342–352. <https://doi.org/10.55730/1300-008X.2772>
- Charoenwoodhipong, P., Zuelch, M. L., Keen, C. L., Hackman, R. M., Holt, R. R. (2025). Strawberry (*Fragaria × Ananassa*) intake on human health and disease outcomes: A comprehensive literature review. *Critical Reviews in Food Science and Nutrition*, 65(25), 4884–4914. <https://doi.org/10.1080/10408398.2024.2398634>
- Yuan, H., Yu, H., Huang, T., Shen, X., Xia, J., Pang, F. et al. (2019). The complexity of the *Fragaria × ananassa* (octoploid) transcriptome by single-molecule long-read sequencing. *Horticulture Research*, 6, Article 46. <https://doi.org/10.1038/s41438-019-0145-3>
- Hasiów-Jaroszewska, B., Zarzyńska-Nowak, A. (2024). Stralarivirus fragariae (latent ring spot of strawberry). *CABI Compendium*, 2024. <https://doi.org/10.1079/cabicompendium.5220>
- Milosavljević, D., Maksimović, V., Milivojević, J., Djekić, I., Wolf, B., Zuber, J. et al. (2023). Sugars and organic acids in 25 strawberry cultivars: Qualitative and quantitative study. *Plants*, 12(12), Article 2238. <https://doi.org/10.3390/plants12122238>
- Newerli-Guz, J., Śmiechowska, M., Drzewiecka, A., Tylingo, R. (2023). Bioactive ingredients with health-promoting properties of strawberry fruit (*Fragaria × ananassa* Duchesne). *Molecules*, 28(6), Article 2711. <https://doi.org/10.3390/molecules28062711>
- Giampieri, F., Forbes-Hernandez, T. Y., Gasparrini, M., Afrin, S., Cianciosi, D., Reboredo-Rodriguez, P. et al. (2017). The healthy effects of strawberry bioactive compounds on molecular pathways related to chronic diseases. *Annals of the New York Academy of Sciences*, 1398(1), 62–71. <https://doi.org/10.1111/nyas.13373>
- Priyadarshi, R., Jayakumar, A., de Souza, C. K., Rhim, J. W., Kim, J. T. (2024). Advances in strawberry postharvest preservation and packaging: A comprehensive review. *Comprehensive Reviews in Food Science and Food Safety*, 23(4), Article e13417. <https://doi.org/10.1111/1541-4337.13417>
- Shahat, M., Ibrahim, M.I., Osheba, A.S., Taha, I.M. (2020). Improving the quality and shelf-life of strawberries as coated with nano-edible films during storage. *Al-Azhar Journal of Agricultural Research*, 45(2), 1–14. <https://doi.org/10.21608/ajar.2020.149403>
- Awulachew, M. T. (2021). Fruit jam production. *International Journal of Food Science, Nutrition and Dietetics*, 10(4), 532–537. <https://doi.org/10.19070/2526-3350-2100092>
- WHO (2025). WHO Sugar Recommendations. Retrieved from <https://www.ages.at/en/human/nutrition-food/nutrition-recommendations/who-sugar-recommendations> Accessed October 8, 2025.
- WHO (2015). WHO calls on countries to reduce sugars intake among adults and children. Retrieved from <https://www.who.int/news/item/04-03-2015-who-calls-on-countries-to-reduce-sugars-intake-among-adults-and-children> Accessed October 8, 2025.

13. Huang, Y., Chen, Z., Chen, B., Li, J., Yuan, X., Li, J. et al. (2023). Dietary sugar consumption and health: Umbrella review. *BMJ*, 381, Article e071609. <https://doi.org/10.1136/bmj-2022-071609>
14. WHO. e-Library of Evidence for Nutrition Actions (eLENA). (2023). Reducing free sugars intake in adults to reduce the risk of noncommunicable diseases. Retrieved from <https://www.who.int/tools/elena/interventions/free-sugars-adults-ncds> Accessed October 8, 2025
15. Beikzadeh, S., Peighambaroudost, S. H., Beikzadeh, M., Javar-Abadi, M. A., Homayouni-Rad, A. (2016). Effect of psyllium husk on physical, nutritional, sensory, and staling properties of dietary prebiotic sponge cake. *Czech Journal of Food Sciences*, 34(6), 534–540. <https://doi.org/10.17221/551/2015-CJFS>
16. Chen, X., Gao, X., Chen, J., Liu, Y., Song, C., Liu, W. et al. (2022). Application of psyllium husk as a friendly filtrate reducer for high-temperature water-based drilling fluids. *ACS Omega*, 7(32), 27787–27797. <https://doi.org/10.1021/acsomega.1c04999>
17. Belorio, M., Gómez, M. (2021). Psyllium: A useful functional ingredient in food systems. *Critical Reviews in Food Science and Nutrition*, 62(2), 527–538. <https://doi.org/10.1080/10408398.2020.1822276>
18. Gordon, D. (2020). FDA approval of added fiber as dietary fiber. *Current Developments in Nutrition*, 4(Suppl_2), 632–632. https://doi.org/10.1093/cdn/nzao049_025
19. Brody, T. (2016). Food and dietary supplement package labeling — Guidance from FDA's warning letters and title 21 of the Code of Federal Regulations. *Comprehensive Reviews in Food Science and Food Safety*, 15(1), 92–129. <https://doi.org/10.1111/1541-4337.12172>
20. Rodrigues, L. M., de Souza, D. F., da Silva, E. A., de Oliveira, T. O., de Lima, J. P. (2017). Physical and chemical characterization and quantification of bioactive compounds in berries and berry jams. *Semina: Ciências Agrárias*, 38(4), 1853–1864. <https://doi.org/10.5433/1679-0359.2017v38n4p1853>
21. Ogunlade, A. O., Oluwafemi, G. I. (2021). Production and evaluation of jam produced from plum and African Star apple blends. *Food Research*, 5(4), 93–98. [https://doi.org/10.26656/fr.2017.5\(4\).031](https://doi.org/10.26656/fr.2017.5(4).031)
22. Agrawal, R. (2021). Psyllium: A source of dietary fiber. Chapter in a book: *Dietary Fibers*. IntechOpen, 2021. <https://doi.org/10.5772/intechopen.99372>
23. Fu, Q.-q., Liu, R., Zhou, L., Zhang, J.-w., Zhang, W.-g., Wang, R.-r. (2022). Effects of psyllium husk powder on the emulsifying stability, rheological properties, microstructure, and oxidative stability of oil-in-water emulsions. *Food Control*, 134, Article 108716. <https://doi.org/10.1016/j.foodcont.2021.108716>
24. Vukoja, J., Pichler, A., Kopjar, M. (2019). Stability of anthocyanins, phenolics and color of tart cherry jams. *Foods*, 8(7), Article 255. <https://doi.org/10.3390/foods8070255>
25. Codex Standard for Jams (Fruit Preserves) And Jellies (Codex Stan 79–1981). Retrieved from https://www.fao.org/input/download/standards/11254/CXS_296e.pdf Accessed October 8, 2025
26. Dubois, M., Gilles, K. A., Hamilton, J. K., Rebers, P. A., Smith, F. (1956). Colorimetric method for determination of sugars and related substances. *Analytical Chemistry*, 28(3), 350–356.
27. AOAC. (2005). Association of Official Analytical Chemists-Official methods of analysis (18th ed.). Washington, DC: AOAC, 2005.
28. Ali, M. A., Hashish, M. H., Fekry, M. M. (2023). Microbiological quality of some packed and unpacked bread products in Alexandria, Egypt. *Journal of the Egyptian Public Health Association*, 98(1), Article 16. <https://doi.org/10.1186/s42506-023-00141-9>
29. Wichchukit, S., O'Mahony, M. (2015). The 9-point hedonic scale and hedonic ranking in food science: Some reappraisals and alternatives. *Journal of the Science of Food and Agriculture*, 95(11), 2167–2178. <https://doi.org/10.1002/jsfa.6993>
30. Mishra, P., Singh, U., Pandey, C. M., Mishra, P., Pandey, G. (2019). Application of Student's t-test, analysis of variance, and covariance. *Annals of Cardiac Anaesthesia*, 22(4), 407–411. https://doi.org/10.4103/aca.ACA_94_19
31. Noman, A. H., Mahin, M. I., Rashid, M. H. A. (2024). Development and consumer acceptance of date jam enriched with apple and orange. *Malaysian Journal of Halal Research*, 7(2), 36–41. <http://doi.org/10.26480/mjhr.02.2024.36.41>
32. Figueroa, L. E., Genovese, D. B. (2020). Structural and sensory analysis of compositionally optimized apple jellies enriched with dietary fibre compared to commercial apple jams. *Journal of Food Science and Technology*, 57(5), 1661–1670. <https://doi.org/10.1007/s13197-019-04199-2>
33. Kassa, M.G., Teferi, D.A., Asemu, A. M., Belachew, M. T., Sateesh, N., Abera, B. D. et al. (2024). Review on psyllium husk: Nutritional, functional, health benefits, food industry applications, waste treatment, and potential negative effects. *CYTA-Journal of Food*, 22(1), Article 2409174. <https://doi.org/10.1080/19476337.2024.2409174>
34. Figueroa, L. E., Genovese, D. B. (2019). Fruit jellies enriched with dietary fibre: Development and characterization of a novel functional food product. *LWT*, 111, 423–428. <https://doi.org/10.1016/j.lwt.2019.05.031>
35. Abutair, A. S., Naser, I. A., Hamed, A. T. (2016). Soluble fibers from psyllium improve glycemic response and body weight among diabetes type 2 patients (randomized control trial). *Nutrition Journal*, 15(1), Article 86. <https://doi.org/10.1186/s12937-016-0207-4>
36. Ho, L.-H., Yasmira, I., Norlia, M. (2020). Proximate composition, physicochemical characteristics and sensory evaluation of reduced-calorie belimbi fruit (*Averrhoa belimbi*) jam with maltitol. *Food Research*, 4(5), 1545–1553. [https://doi.org/10.26656/fr.2017.4\(5\).090](https://doi.org/10.26656/fr.2017.4(5).090)
37. Yadav, M., Hossain, S. A., Bharti, B.K., Jaiswal, M. (2018). Comparative study of physico-chemical property in different brands of jam, honey and jelly. *Journal of Pharmacognosy and Phytochemistry*, 7(5), 2186–2191.
38. Brandão, T. M., do Carmo, E. L., Elias, H. E. S., de Carvalho, E. E. N., Borges, S. V., Martins, G. A. S. (2018). Physicochemical and microbiological quality of dietetic functional mixed cerrado fruit jam during storage. *The Scientific World Journal*, 2018(1), Article 2878215. <https://doi.org/10.1155/2018/2878215>
39. Kayshar, M. S., Saifullah, M., Rahman, A., Uddin, M. B. (2014). An overview of quality status of selected commercial brands of juices and jams based on public perception and laboratory analysis. *Journal of the Bangladesh Agricultural University*, 12(1), 183–188. <https://doi.org/10.3329/jbau.v12i1.21410>
40. Abolila, R. M., Barakat, H., El-Tanahy, H. A., El-Mansy, H. A. (2015). Chemical, nutritional and organoleptical characteristics of orange-based formulated low-calorie jams. *Food and Nutrition Sciences*, 6(13), 1229–1244. <https://doi.org/10.4236/fns.2015.613129>
41. Banaś, A., Korus, A., Tabaszewska, M. (2018). Quality assessment of low-sugar jams enriched with plant raw materials exhibiting health-promoting properties. *Journal of Food Science and Technology*, 55(1), 408–417. <https://doi.org/10.1007/s13197-017-2952-6>
42. Shinwari, K. J., Rao, P. S. (2020). Development of a reduced-calorie high pressure processed sapodilla (*Manilkara zapota* L.) jam based on rheological, textural, and sensory properties. *Journal of Food Science*, 85(9), 2699–2710. <https://doi.org/10.1111/1750-3841.15364>
43. Ogori, A.F., Amove, J., Evi-Parker, P., Sardo, G., Okpala, C.O.R., Bono, G. et al. (2021). Functional and sensory properties of jam with different proportions of pineapple, cucumber, and *Jatropha* leaf. *Foods and Raw Materials*, 9(1), 192–200. <https://doi.org/10.21603/2308-4057-2021-1-192-200>
44. Mohammadi-Moghaddam, T., Firoozzare, A., Daryadar, S., Rahmani, Z. (2020). Black plum peel jam: Physicochemical properties, sensory attributes, and antioxidant capacity. *International Journal of Food Properties*, 23(1), 1737–1747. <https://doi.org/10.1080/10942912.2020.1830798>
45. Maimaitiyiming, R., Zhang, H., Wang, J., Wang, L., Zhao, L., Liu, B. et al. (2024). A novel strategy for mixed jam evaluation: Apparent indicator, sensory, metabolic, and GC-IMS analysis. *Foods*, 13(7), Article 1104. <https://doi.org/10.3390/foods13071104>



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Conflict of interest	Конфликт интересов
<p>The authors declare no conflict of interest.</p>	<p>Авторы заявляют об отсутствии конфликта интересов.</p>