QUALITATIVE PROPERTIES OF COOKIES ENRICHED WITH NATURAL STRAWBERRY POWDER

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Abstract;

This study aimed to evaluate the qualitative properties of cookies enriched with strawberry powder (SP), a nutrient-dense ingredient that enhances the nutritional value of bakery products. Strawberry powder is a rich source of vitamins, antioxidants, dietary fiber, and minerals, which are beneficial for human health. The experiment involved preparing cookies with different levels of SP 10%, 15%, and 20% as a partial replacement with wheat flour (WF), and their physical, chemical, and sensory properties were analyzed. The results indicated that the incorporation of SP into cookies improved the nutritional profile, with the 20% SP cookies showing increased moisture (16.66%), protein (10.50%), fiber (10.11%), fat (4.60%), and ash (3.30%). as well as enhanced levels of vitamins, particularly vitamin C (3.30 µg/g), folate (2.340 µg/g), and B-vitamins such as B1 (1.908 µg/g), B2 (1.099 µg/g), B3 (1.40 µg/g), and B6 (1.507 µg/g) in 20% of SP. A higher level of (SP) led to increases in total phenolic content (TPC), total anthocyanin content (TAC), and antioxidant activity. Sensory evaluation showed that cookies with 10% SP received the highest acceptability scores (8.3), especially for taste (8.1), texture (7.9), odor (7.7), color (7.7), and hardness (8.1). However, cookies with (15% and 20%) SP scored lower in taste (5.6) and texture (6.3). The study concludes that the addition of 10% strawberry powder significantly improves the nutritional and sensory properties of cookies, making them a healthier snack option.

Keywords: Strawberry powder, Wheat flour, Cookies product. Nutritional value.

1.INTRODUCTION

The food processing industry has advanced significantly with scientific and technological progress, continuously adopting global innovations [1]. The demand for nutrient-dense foods that promote health and offer additional benefits is increasing [2]. Functional foods, particularly those rich in dietary fiber and antioxidants, have gained attention. Bakery products like cookies are a notable example [3]. However, confectionery items, though widely consumed, are typically high in energy but lack essential nutrients, making them less ideal for a balanced diet [4].

Although fruits and vegetables are the primary sources of antioxidants and help lower the risk of diseases, strawberry powder (SP) stands out as a highly nutritious option [5], [6]. It serves as a natural additive that enhances cookies with vital nutrients, including vitamins, natural antioxidants, protein, fiber, and minerals [7].

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Strawberries are highly perishable and delicate due to their high respiration rate, rapid weight loss, and susceptibility to fungal contamination [8]. After harvest, they are prone to microbial and chemical decay, which significantly reduces their shelf life [9]. To extend their usability, strawberries are often preserved through drying, freezing, or converting them into powder for use in various industrial products [10.]

Strawberries contain various essential compounds that contribute to the prevention and management of numerous diseases [11]. They have been found to impact cancer and cancer cells while also aiding in the reduction of blood cholesterol levels. Additionally, strawberries help enhance the antioxidant capacity of human plasma [12]. The antioxidants present in strawberries also play a role in boosting the activity of low-density lipoproteins (LDL) and exhibit anti-carcinogenic properties in humans [13.]

In addition, wheat flour (WF), the main component of cookies, is rich in carbohydrates but deficient in essential minerals, fiber, and beneficial bioactive compounds like antioxidants [14]. To boost the nutritional value of cookies, different ingredients, such as strawberry powder, can be added [15]. These enhancements not only improve the health benefits of cookies but also introduce a variety of flavors, textures, and nutrients, enabling consumers to enjoy a delicious snack with extra nutritional advantages [16.]

Cookies from various types of bakeries are widely consumed by people of all age groups due to their enjoyable taste [17]. Many studies have focused on enhancing the nutritional value of cookies by incorporating different ingredients [18]. Strawberries are a nutrient-rich fruit that serve as an excellent source of vitamins, antioxidants, fiber, and natural color [19]. Therefore, this study aims to evaluate the quality characteristics of cookies made with varying amounts of strawberry powder.

2.MATERIALS AND METHODS

2.1Matrials preparation

The primary materials used in this experiment for producing cookies included strawberry powder (SP) combined with soft wheat flour (WF) in varying ratios. Additionally, other ingredients necessary for cookie production are listed in Table 1. All materials were prepared in the laboratory of the Department of Food Science and Quality Control at the College of Agricultural Engineering Sciences, University of Sulaimani.

Table 1: Presents the ratios of wheat flour (WF) alone and in combination with strawberry powder (SP), along with other ingredients used in the cookie formulation.

Cookies Sample	Cookies Formula	Other Ingredient of Cookies
Control	100 gram WF with other components.	1g of baking powder, 1g salt, 40g of sugar, 20g Skimmed milk powder, 20g of egg, 50g butter, and 20 ml of Water, if required.
SP 10%	WF 90 gram + 10 gram SP	
SP 15%	WF 85 gram + 15 gram SP	
SP 20%	WF 80 gram + 20 gram SP	

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2.2 Preparing strawberry powder

Local strawberry varieties were sourced from the Sulaimani market and dried using a hot air dryer (Kenwood model SC250D) to produce strawberry powder. Initially, the strawberries were washed with tap water and de-stemmed. They were then sliced evenly into thin pieces, approximately 1/8 inch thick, using a knife. These slices were quickly and uniformly arranged on the tray of the food dehydrator Then they dried at 55°C for 14 hours. Once fully dried, the strawberries were stored in an airtight container at room temperature. Finally, they were ground using a miller model KA3117 to obtain fine strawberry powder.

2.3 Cookie dough preparation process for bakeries

The ingredients, once clarified from Table 1, were mixed until a cream-like consistency was achieved. Then, wheat flour was added and mixed for 4 minutes until cookie dough was formed.The same procedure was followed for cookies in other treatments. The dough was then refrigerated at 6 °C for 30 minutes. After refrigeration, it was rolled out to a thickness of 4 mm, cut into circular shapes with a 5 cm diameter by using a cookie cutter, and placed on a baking tray lined with baking paper. The cookies were then baked in a preheated electronic oven (DLC model 2095BL) at 170 °C for 10 minutes. Finally, the baked cookies were cooled to room temperature for 2 hours, packed in sealed plastic bags, and stored until used for chemical analysis.

Before using the SP and WF in this experiment, samples were taken for laboratory analysis to determine their composition. This analysis aimed to compare the components and identify the most suitable substitute while assessing the chemical composition of the ingredients. Table 2 presents the composition of strawberry powder and wheat flour (g/100g) on a dry weight basis (%).

Table 2: Proximate composition of SP and WF on a dry weight basis (g/100g).

Composition	SP	WF
Moisture	11.01	8.780
Fat	1.27	1.200
protein	7.14	12.70
ash	4.10	0.560
fiber	25.24	2.120
Carbohydrate (by differences)	51.24	74.64

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Folate (milligram per100g)	0.221	0.183
Thiamine(milligram per100g)	0.180	0.120
Riboflavin (milligram per 100g)	0.640	0.510
Niacin (milligram per 100 g)	2.090	0.480
Pyridoxine (milligram per100g)	0.550	0.066
Vit. C (milligram per 100g)	42.40	0.000 (N.D)
TPC (mg GAE per 100g)	480.0	0.590
TAC (mg C3G per 100g)	831.00	0.000 (N.D)
Antioxidant activity (DPPH %)	82.150	11.80

2.4. Chemical analysis for cookie products

The chemical analysis of cookies in this experiment involved determining of moisture, protein, ash, fiber, and fat content. Carbohydrate content was calculated by difference. All the methods used were those referenced in [20].

2.5. Total phenolic content in cookies product with powder of wheat flour and strawberry

The Total Phenolic Content (TPC) was measured in wheat cookies and those fortified with 0%, 10%, 15%, and 20% SP, as well as in strawberry powder and wheat flour. The Folin-Ciocalteu method was used, where samples were ground, extracted with ethanol, and filtered before reacting with the Folin-Ciocalteu reagent. Absorbance was measured at 760 nm using a spectrophotometer model Shimadzu 180A Uv-visible, and TPC was determined through a calibration curve with gallic acid standards. The results, expressed as milligrams of gallic acid equivalents (GAE) per gram, provide insight into the antioxidant potential of the cookies [9] and [21].

2.6. Anthocyanin Content in Cookie Composition and Cookie Products

The Total anthocyanin content (TAC) in wheat, WF, SP, control cookies, and cookies fortified with 5%, 10%, and 20% SP was determined through a series of steps, including extraction, standard solution preparation, and quantification. Anthocyanins were extracted using a methanol-water-(1N) acetic acid solvent in a ratio of 70:28:2,then homogenized, filtered, and analyzed. Absorbance was measured at 520 nm. The anthocyanin concentration in the samples was then determined based on the cyanidin-3-glucoside, ensuring accurate quantification [22].

2.7. Determining Antioxidant Activity in Cookies product

Antioxidant activity in plain wheat cookies and those fortified with 0%, 10%, 15%, and

20% SP is evaluated using DPPH and ABTS assays, which assess the ability to scavenge free radicals. For sample preparation, plain and fortified cookies are finely ground and sieved (60-80 mesh) to ensure uniform particle size. Strawberry powder and wheat flour are used directly without further processing. In the DPPH assay, a 0.025 mg/L DPPH solution was prepared in methanol and protected from light. For extraction, 1g of each powdered sample was mixed with 10mL of 80% methanol containing 0.1% HCl, then vortexed for 5 minutes, sonicated for 30 minutes, and centrifuged at 4000 rpm for 10 minutes. The supernatant was collected and stored at 4°C. For the reaction setup, 100 µL of extract was added to 3.9 mL of DPPH solution, incubated in the dark for 30 minutes at room temperature, and measured at 517 nm using a UV-Vis spectrophotometer [23]. Antioxidant activity is calculated using the % inhibition formula:

Inhibition % =(AC-AS)/AC×100

When: AC= Absrobance of control, AS= Absorbance of sample.

2.8. Determination of vitamin content in the cookie products

The method used to analyze the soluble vitamin in different samples, such as cookie products, wheat-fortified strawberries, SP, and WF, was based on the approaches outlined in previous studies [24]– [27].

2.9. Analysis of physical characteristics of cookie products

The physical characteristics of the cookie product were analyzed 24 hours after baking. Additionally, properties such as weight, width, thickness, and spread ratio were evaluated using the methods described by [28].

2.10. Sensory evaluation

A 9-point hedonic scale was utilized for the sensory evaluation of cookie products, with ratings from 1 (strong dislike) to 9 (strong preference). Ten panelists were selected to assess the sensory attributes including color, flavor, aroma, hardness, and texture [22].

2.11. Statistical data analysis

Statistical data analysis using XLSTAT program for window, while to the comparisons of mean applied Duncan's test at significance level of P ≥0.05. The obtained data were carried out in triplicates, unless otherwise stated.

3. RESULTS AND DISCUSSION

The data presented in Table 3 indicate the results of the chemical composition analysis of the experiment conducted on wheat flour (WF) alone and its mixtures with strawberry powder (SP) in different ratios for cookie production. The findings revealed statistically significant differences compared to the control. The percentages of moisture, protein, fat, ash, and fiber increased with higher SP substitution. the highest moisture content was observed in cookies containing 20% SP (16.66%, 10.50%, 4.60%, and 10.11 %) respectively. This increase in moisture may be attributed to the hygroscopic properties of SP, which attract and retain water. Additionally, the smaller particle size of SP increases the surface area, leading to greater water absorption and retention [3]. In contrast, the control sample (100% WF) recorded the lowest value for moisture, protein, fat, ash, and fiber (9.66%, 9.33%, 4.00%, 2.80%, and 7.50%) respectively. Conversely, the highest carbohydrate content was found in the control sample (66.71%), whereas the lowest was recorded in cookies with 20% SP (54.83%). This decrease corresponds to the increase in fiber and other components contributed by the strawberry powder.

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Table 3: Comparative Analysis of the Chemical Composition of Cookie Products with Varying Levels of Strawberry Powder (g/100 g, Dry Weight)

Cookies sample	Moisture %	Protein%	Fat%	Ash%	Fiber%	Carbohydrate %
control	9.66 [d]	9.33 [d]	4.00 [a]	2.80 [c]	7.50 [d]	66.71 [a]
10%	11.66 [c]	10.03 [c]	4.40 [a]	2.90 [c]	8.82 [c]	62.19 [b]
15%	13.33 [b]	10.26 [b]	4.60 [a]	3.10 [b]	9.12 [b]	59.59 [c]
20%	16.66 [a]	10.50 [a]	4.60 [a]	3.30 [a]	10.11 [a]	54.83 [d]

These results suggest that the addition of SP directly influenced the chemical composition of the cookies. As SP was incorporated, the levels of moisture, protein, fat, ash, and fiber increased, except for carbohydrates, which decreased due to wheat flour being naturally rich in carbohydrates [28,29]. Moreover, drying, baking, and processing can lead to slight degradation or loss of some sugars including caramelization or the Maillard reaction, which reduces the total carbohydrate content [6]. Furthermore, the findings indicate that incorporating SP enhanced the nutritional composition of the cookies,and improved their overall quality . These findings are consistent with previous studies that have focused on cookies and the addition of certain ingredients to cookie products [30]. Table 4 presents the values for total phenolic content (TPC), total anthocyanin content (TAC), and antioxidant activity. The results indicate a significant difference compared to the control. Furthermore, the proportion of SP in the cookie formulation increased, the levels of TPC, TAC, and antioxidant activity also rose. This correlation is attributed to the high levels of these compounds in strawberries compared to WF [31, 1, 7.]

Table 4: Evaluation of TPC, TAC, and antioxidant activity (DPPH radical scavenging activity) in various cookie products.

Cookies Sample	TPC (mg GAE /gram)	TAC (mg C3G /gram)	Antioxidant activity (DPPH%)
Control (0%)	141.85 [d]	0.00 [d] (n.d)	6.36 [d]
10%	174.15 [c]	10.86 [c]	40.20 [c]
15%	193.32 [b]	16.27 [b]	50.51 [b]
20%	207.47 [a]	20.17 [a]	64.93 [a]

GAE= Gallic acid equivalent, C3G= Cyaniding 3 glucoside

Additionally, the highest TPC, TAC, and antioxidant activity were observed in the treatment 20% SP, with TPC values at 207.47 mg GAE/g, TAC 20.17 mg C3G/g, and antioxidant (DPPH) 64.93% respectively. These findings align with previous studies [30, 17, 15]. Conversely, the lowest values were recorded in the control sample, with TPC at 141.85 mg GAE/g, no measurable TAC, and antioxidant activity at 6.36% DPPH. The absence of TAC in the control sample is expected since WF does not contain anthocyanins, which explains

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why TAC was not detected in that treatment [16, 30, 32].

Table 5 displays the vitamin content of various cookie formulations, including the control sample (0%) and those with different substitution levels (10%, 15%, and 20%). The findings indicate a consistent pattern where higher substitution levels correspond to increased vitamin content. The control sample, composed entirely of WF, contains the lowest levels of all vitamins, with vitamin C being undetectable (n.d). As the substitution level rises, there is a significant increase in vitamin C, folate (B9), thiamine (B1), riboflavin (B2), niacin (B3), and pyridoxine (B6). The highest concentrations are found in the 20% SP formulation, where vitamin C reaches 3.300 µg/g, folate 2.340 µg/g, thiamine 1.908 µg/g, riboflavin 1.099 µg/g, niacin 1.400 µg/g, and pyridoxine1.507µg/g

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Table 5: Provides an overview of the findings regarding the vitamin content in different types of cookie products.

Cookie samples	Vit .C Microgram\ g	Folate (B 9) Microgram\g	Thiamine (B1) Microgram\ g	Riboflavin (B2) Microgram\ g	Niacin (B3) Microgram\ g	Pyridoxine (B6) Microgram\ g
Control 0%	0.00 ^{d} (n.d)	0.690 ^{d}	0.080 ^{d}	0.140 ^{d}	0.283 ^{d}	0.250 ^{d}
10%	3.016 ^{c}	1.570 ^{c}	0.926 ^{c}	0.822 ^{c}	1.060 ^{c}	0.930 ^{c}
15%	3.210 ^{b}	1.670 ^{b}	1.109 ^{b}	0.927 ^{b}	1.100 ^{b}	1.200 ^{b}
20%	3.300 ^{a}	2.340 ^{a}	1.908 ^{a}	1.099 ^{a}	1.400 ^{a}	1.507 ^{a}

Additionally, when comparing the control sample to the treatments, the control (0%) exhibits the lowest vitamin content across all categories, with vitamin C being entirely absent. The 10% SP substitution results in a noticeable increase, with vitamin C rising to 3.016 µg/g and other vitamins also showing significant improvement. The 15% SP substitution continues this upward trend, yielding slightly higher vitamin levels than the 10% SP formulation. Ultimately, the 20% SP substitution achieves the highest vitamin content among all treatments, confirming that greater substitution enhances the cookies' nutritional profile.

The variations in vitamin content can be attributed to the incorporation of nutrient-rich ingredients in the treatment formulations. The control sample, consisting solely of WF, naturally contains lower vitamin levels [33]. However, as the SP percentage increases, the inclusion of SP contributes additional vitamins, significantly improving the cookies' nutritional quality [34]. These differences are statistically significant, with the highest substitution level (20% SP) providing the greatest enhancement in vitamin content.

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The physical characteristics of cookies, including weight, thickness, diameter, and spread ratio, were significantly influenced by the partial substitution of wheat flour with strawberry powder at different levels (10%, 15%, and 20%), as shown in Table 6. statistically significant increase in cookie weight was observed with the addition of strawberry powder. The 10% substitution sample had the highest weight (9.90 g), followed closely by the 15% (9.85 g) and 20% (9.77 g) samples, all of which were significantly heavier than the control (9.69 g). This suggests that the inclusion of strawberry powder may enhance moisture retention or density of the dough [35, 36]. However, the results showed a significant decrease in the spread ratio due to the fiber content, which retarded the spreading of the cookies and increased their thickness with substitution.The 10% and 15% strawberry powder cookies shared the highest thickness (4.987 mm), significantly higher than the control (4.930 mm).

The 20% sample showed a slightly lower thickness (4.963 mm) than 10% and 15%, but still significantly greater than the control. In contrast, cookie diameter decreased significantly with increasing levels of strawberry powder. The control sample had the largest diameter (55.867 mm), while the 20% substitution sample had the smallest (50.637 mm). This reduction may be attributed to changes in dough structure and spreadability caused by the fiber and water-binding properties of strawberry powder [35 , 36]. These results clearly demonstrate that incorporating strawberry powder in place of wheat flour significantly affects the physical properties of cookies. Moderate substitution levels (10–15%) resulted in increased weight and thickness while maintaining acceptable spread and diameter. However, higher substitution (20%) notably reduced spread and diameter, suggesting a potential limit for maintaining desirable cookie characteristics.

Table 6: Physical characteristics of cookie with varying levels of strawberry powder.

Cookies Sample	Weight (g)	Thickness (mm)	Diameter (mm)	Spread ratio
Control (0%	**9.69** ^{d}	**4.930** ^{c}	**55.867** ^{a}	**11.332** ^{a}
10%	**9.90** ^{a}	**4.987** ^{a}	**51.870** ^{b}	**10.401** ^{b}
15%	**9.85** ^{b}	**4.987** ^{a}	**51.880** ^{c}	**10.403** ^{b}
20%	**9.77** ^{c}	**4.963** ^{b}	**50.637** ^{d}	**10.202** ^{c}

Table 7 presents the sensory evaluation results for different cookie samples, assessing characteristics such as color, taste, aroma, hardness, texture, and overall acceptability. The sensory ratings are expressed as mean values, with statistical significance denoted by distinct superscripts letters. Higher scores indicate a greater preference for a specific attribute.

The findings reveal that the cookies with a 10% SP substitution received the highest overall acceptability score (8.30) and ranked highest in nearly all sensory attributes, including taste (8.10), odor (7.70), hardness(8.10), and texture (7.90). The control sample (0% SP, 100% WF) also obtained high ratings but had a slightly lower overall acceptability score (7.70).

Meanwhile, the 15% SP substitution showed comparable results to the control, with no significant differences in most attributes. In contrast, the cookies with 20% SP substitution

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exhibited significantly lower scores in all sensory aspects, particularly taste (5.60) And overall acceptability (6.0), suggesting a decline in quality with higher SP content.

Table 7: Sensory evaluation for cookies products with varying levels of strawberry powder

Cookies Sample	color	Taste	Odor	Hardness	Texture	Overall acceptability
Control (0%)	7.400 ^{ab}	7.500 ^{a}	7.100 ^{ab}	7.600 ^{a}	7.500 ^{a}	7.700 ^{ab}
10%	7.700 ^{a}	8.100 ^{a}	7.700 ^{a}	8.100 ^{a}	7.900 ^{a}	8.300 ^{a}
15%	7.300 ^{ab}	7.400 ^{a}	7.300 ^{a}	7.500 ^{a}	7.400 ^{a}	7.400 ^{b}
20%	6.700 ^{b}	5.600 ^{b}	6.200 ^{b}	6.700 ^{b}	6.300 ^{b}	6.000 ^{c}

When comparing the 10% SP sample with the control (0% SP), the 10% SP cookies achieved slightly higher scores across all attributes, especially in taste, aroma, texture, and overall acceptability. This improvement could be attributed to the mild sweetness and enhanced flavor contributed by the SP, which made the cookies more appealing without drastically altering their texture. Similarly, the comparison between the 15% SP sample and the control showed that the 15% SP cookies had similar ratings, indicating that a moderate level of SP substitution did not significantly affect the sensory properties. On the other hand, the 20% SP substitution performed considerably worse than all other treatments, with significantly lower ratings across all sensory attributes. The decline in quality may be due to the higher SP altering the cookie's texture, making it denser or drier, and affecting the taste by introducing a strong, less preferred flavor. the results suggest that incorporating up to 10% SP enhances sensory attributes, making the cookies more appealing. However, increasing the SP content beyond 15% negatively impacts key sensory properties such as taste, hardness, and overall acceptability. Therefore, 10% SP appears to be the optimal substitution level, balancing both sensory quality and nutritional benefits.

4.CONCLUSION

The incorporation of strawberry powder (SP) into cookies significantly enhanced their nutritional profile, by increasing levels of antioxidants, vitamins, fiber, and other essential nutrients. Among the various concentrations tested, cookies with 10% SP exhibited the best balance of improved nutritional content and sensory acceptability. These cookies demonstrated higher antioxidant activity, a greater quantity of beneficial vitamins, and an appealing taste and texture. On the other hand, higher concentrations of SP (15% and 20%) negatively impacted the sensory properties particularly in term__taste and overall acceptability. This suggests that a 10% substitution of wheat flour with strawberry powder is optimal for improving the quality of cookies without compromising their consumer appeal. Additionally moderate substitution of wheat flour with strawberry powder improves the physical properties of cookies without compromising quality . However, higher substitution levels negatively affect these physical properties indicating a threshold for effective use. The findings indicate that SP-enriched cookies are a

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promising option for the production of functional snacks that offer both nutritional and health benefits.

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