FORMULATION OF FUNCTIONAL ORANGE JELLIES ENRICHED WITH ROSEHIP POWDER

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Abstract
The contemporary food industry increasingly focuses on developing functional products that meet consumer demand for a healthy and balanced diet. This study aimed to develop healthier orange jelly formulations by incorporating rosehip powder (RP), a valuable unconventional ingredient rich in bioactive compounds. In this study, RP was incorporated into a conventional orange juice jelly recipe at concentrations of 0% (control), 2%, 4%, and 6% (w/w). Both the rosehip powder and the resulting jelly formulations were analyzed for total phenolic content (TPC), total flavonoid content (TFC), vitamin C, and antioxidant capacity, expressed as ferric reducing antioxidant power (FRAP), as key indicators of their functional properties. The rosehip powder exhibited high levels of total phenolic content (TPC: 2015.89 mg GAE/100 g d.w.), total flavonoids (TFC: 1280.42 mg QE/100 g d.w.), vitamin C (992.71 mg/100 g d.w.), and antioxidant capacity measured as FRAP (469.38 µM Fe^{2+}/g d.w.). By supplementing orange jelly with RP at levels of 2%, 4%, and 6%, increases of 8.93%, 17.19%, and 25.81% in TPC, 9.73%, 20.48%, and 28.91% in TFC, 15.88%, 32.34%, and 46.51% in FRAP, and 31.73%, 61.70%, and 87.05% in vitamin C were observed compared to the control. These results indicate that RP is a rich source of polyphenols and vitamin C, substantially contributing to the antioxidant activity and functional properties of food products. In the RP-enriched jelly formulations, levels of bioactive compounds and antioxidant activity increased progressively, reaching their highest values in the 6% RP sample. Overall, the study demonstrates that RP represents a promising functional ingredient for jelly fortification. Its incorporation enhances the antioxidant profile, offering a promising strategy for developing value-added, health-supporting foods.

Key words: rosehip powder; fortified orange jellies; bioactive compounds; functional profile

Introduction

The food industry is increasingly focused on developing functional products that meet consumer demand for healthy nutrition. Gelatin-based confectionery products, such as jellies, are characterized by a soft, translucent, and elastic texture, combined with a sweet and slightly tart taste. Typically made from sugar, glucose syrup, and gelling agents, along with colors, flavors, and acids, jellies offer a unique texture and visual appeal and are enjoyed across all age groups. The color, flavor, and overall sensory quality largely depend on the choice of fruit ingredients, while the firm yet elastic texture is achieved through gelling agents such as agar-agar, pectin, gelatin, gum arabic, or starch [1, 2]. Growing consumer interest in healthy foods has prompted the development of enriched jellies through the incorporation of plant-based ingredients rich in bioactive compounds [2]. Rosehip powder, derived from various *Rosa* species, has attracted attention as a functional ingredient due to its high content of vitamin C, carotenoids, polyphenols, and dietary fiber, which provide antioxidant and anti-inflammatory benefits [3–6]. It provides both nutritional and technological benefits, enhancing the functional properties of food products [7–9]. Despite its widespread use in bakery products, the application of rosehip powder in jelly formulations remains limited. Jellies can serve as an excellent vehicle for functional ingredients without compromising sensory attributes. Therefore, this study aims to evaluate the effects of incorporating rosehip powder at 0%, 2%, 4%, and 6% (w/w) into an orange juice jelly, focusing on its potential to enhance bioactive compounds, antioxidant capacity, and overall functional properties of the resulting formulations.

Experimental

Preparation of rosehip-enriched jellies

Control jellies were made with 400 mL of orange juice, 20 g of gelatin, and 10 g of sugar. Three formulations of enriched jellies were prepared from the base recipe by adding rosehip powder at 2, 4, or 6% (w/w). Gelatin was hydrated in the juice for 10 minutes, then sugar was added. Each mixture was gently heated to 55 °C to dissolve the gelatin and initiate gelation, then poured into molds and allowed to set at room temperature. Once fully gelled, jellies were removed from the molds and cooled completely. The final products were coded as J (control), J+2%RP, J+4%RP, and J+6%RP. Both RP and jellies were analyzed for total phenolic content (TPC), total flavonoid content (TFC), vitamin C, and antioxidant capacity (FRAP) to assess their functional properties.

Analytical procedures

Preparation of alcoholic extracts for phytochemical and antioxidant analysis. RP and jellies were extracted with 70% ethanol by mixing 0.5 g of sample with 10 mL solvent. The mixture was stirred at room temperature for 2 h and centrifuged at 10,000 rpm for 10 minutes. The residue was re-extracted under the same conditions for an additional 60 minutes [10]. Supernatants from both steps were combined, adjusted to 20 mL with ethanol, and stored at −20 °C in the dark until further analysis of total phenolic and flavonoid contents, as well as antioxidant activity. All extractions were performed in triplicate..

Determination of total phenolic content (TPC). The total phenolic content was assessed using the Folin–Ciocalteu method [11]. Diluted extracts (1:10, v/v) were mixed with Folin–Ciocalteu reagent and sodium carbonate solution, then incubated at 50 °C for 30 minutes. Absorbance was recorded at 750 nm, and TFC was calculated from a gallic acid calibration curve. Results were expressed as mg gallic acid equivalents (GAE) per gram of dry weight.

Evaluation of total flavonoid content (TFC). Flavonoid concentration was assessed using a colorimetric method described by Al-Farsi et al. [12]. Extracts were treated with sodium nitrite, aluminum nitrate, and sodium hydroxide, then diluted to volume with 70% ethanol. After incubation at room temperature, absorbance was measured at 510 nm. Quantification was based on a quercetin calibration curve, and results were expressed as mg quercetin equivalents (QE) per 100 g dry weight of sample.

Determination of vitamin C content. Vitamin C content was determined by titration with 2,6-dichlorophenol-indophenol solution. 1 g of fruit powder was extracted with oxalic acid, filtered, treated with kaolin, and re-filtered to obtain a clear solution. An aliquot was titrated until a persistent pink endpoint appeared. The results were calculated and expressed as mg/100 g dry weight of sample, according to Žlabur et al. [13] with slight modifications.

Antioxidant activity by FRAP assay. The antioxidant capacity of samples was evaluated using the FRAP method, which measures the reduction of ferric (Fe^{3+}) to ferrous (Fe^{2+}) ions, forming a blue Fe^{2+}–TPTZ complex with absorption at 593 nm [14]. Diluted extracts were mixed with FRAP reagent and incubated at 37 °C for 30 minutes. Absorbance was recorded at 593 nm, and antioxidant activity was calculated from a $FeSO_4$ calibration curve. Results were expressed as µM Fe^{2+} equivalents per gram dry weight of sample.

Statistical analysis

All results were expressed as mean ± standard deviation (SD). Differences between jelly samples were evaluated using one-way analysis of variance (ANOVA).

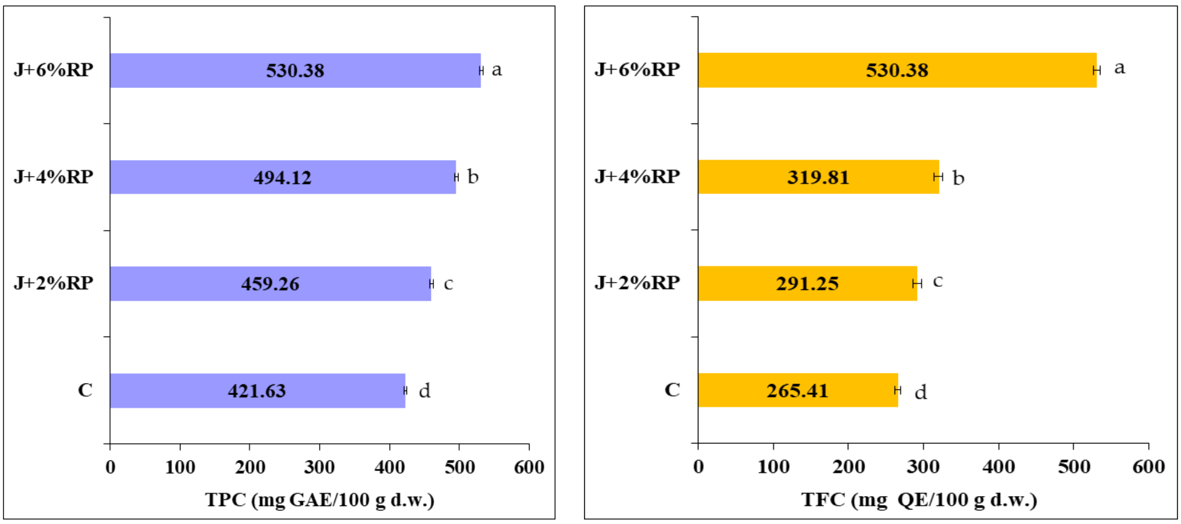
Results and discussion

The characteristics of the rosehip powder used as a functional food ingredient to enhance the antioxidant properties and bioactive compound content of the jellies are presented in Table 1.

Table 1. Bioactive compound content and total antioxidant capacity of rosehip powder

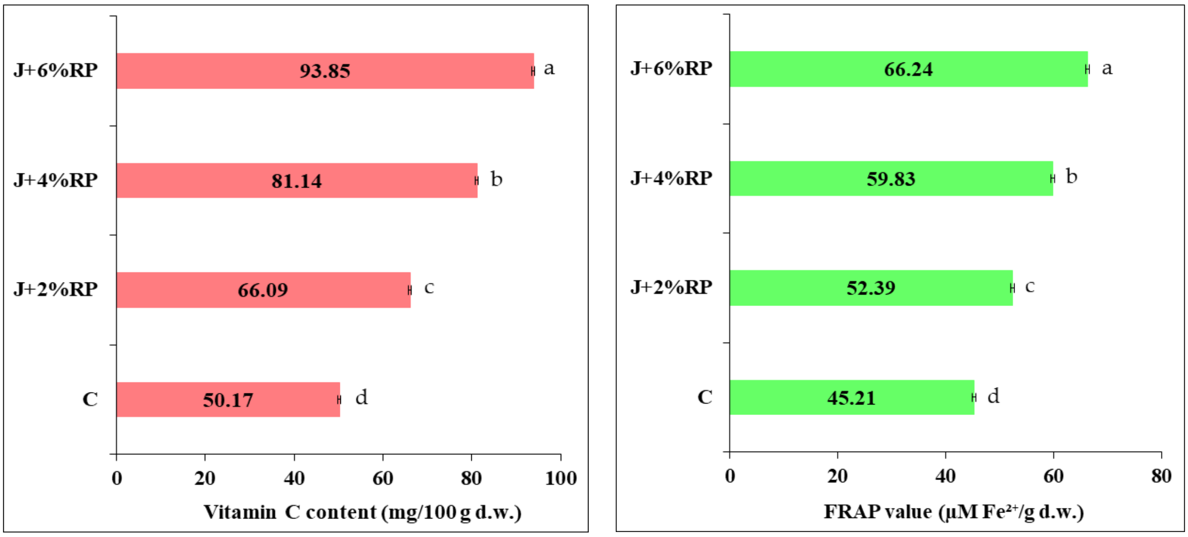
Investigated parameter	Value
TPC (mg GAE/100 g d.w.)	2015.89 ± 3.47
TFC (mg GAE/100 g d.w.)	1280.42 ± 3.12
FRAP (µM Fe^{2+}/g d.w.)	469.38 ± 1.32
Vitamin C (mg/100 g d.w.)	992.71 ± 3.69

The rosehip powder was characterized by a high TPC (2015.89 mg gallic acid equivalents, GAE/100 g d.w.), TFC (1280.42 mg quercetin equivalents, QE/100 g d.w.), vitamin C content (992.71 mg/100 g d.w.), and ferric reducing antioxidant power (FRAP: 469.38 µM Fe^{2+}/g d.w.). These results indicate that RP is a valuable source of polyphenolic compounds in addition to its high vitamin C content. These bioactive compounds contribute significantly to the antioxidant properties of the powder, as reflected by the elevated FRAP value. Thus, RP represents a valuable non-conventional ingredient that can be used to enhance the functional properties of food products. The functional potential of rosehip powder was utilized by incorporating it into an orange juice jelly formulation. The resulting jelly formulations were analyzed for total phenolic content, vitamin C, and antioxidant capacity, as key indicators of their functional profile. The characteristics of the RP-enriched jellies are presented in Figures 1 (TPC, TFC) and Figure 2 (vitamin C and FRAP value).



(**a**) (**b**)

Figure 1. Total phenolic content (**a**) and total flavonoid content (**b**) of rosehip powder-enriched jellies compared to the control



(**a**) (**b**)

Figure 2. Vitamin C content (**a**) and total antioxidant capacity (**b**) of rosehip powder-enriched jellies compared to the control

The results clearly demonstrate that incorporating RP into the orange juice jelly formulation positively influenced its functional properties. The total polyphenol content (TPC) increased progressively with the level of RP: 459.26, 487.32, and 530.38 mg GAE/100 g d.w. for 2%, 4%, and 6% RP, respectively, representing increases of 8.93%, 17.19%, and 25.81% compared to the control (421.63 mg GAE/100 g d.w.). Similarly, the total flavonoid content (TFC) increased from 265.45 mg QE/100 g d.w. in the control to 291.25, 319.83, and 342.19 mg QE/100 g d.w., corresponding to enhancements of 9.73%, 20.48%, and 28.91%. The vitamin C content showed substantial improvements, increasing from 50.17 mg/100 g d.w. in the control to 66.09, 81.14, and 93.85 mg/100 g d.w. in the 2%, 4%, and 6% RP-enriched jellies, respectively, reflecting increases of 31.73%, 61.70%, and 87.05%. The antioxidant capacity also improved significantly with increasing RP levels. FRAP values increased from 45.21 µM Fe^{2+}/g d.w. in the control to 52.39, 59.83, and 66.24 µM Fe^{2+}/g d.w. in the 2%, 4%, and 6% RP jellies, corresponding to improvements of 15.88%, 32.34%, and 46.51%, highlighting a clear dose-dependent effect. The results indicate that higher RP levels boosted bioactive compounds and antioxidant capacity in the jellies, confirming its role as a valuable functional ingredient.

Conclusion

Rosehips are an accessible and rich source of bioactive compounds, including vitamin C, polyphenols, and antioxidants, making them an ideal functional ingredient for food products. Rosehip powder, due to its pronounced bioactive properties, represents a valuable non-conventional material for enhancing the functional quality of foods. Incorporation of 2%, 4%, and 6% rosehip powder into an orange juice jelly formulation improved its functional profile, with the highest levels of total phenolic content (TPC), total flavonoid content (TFC), vitamin C, and ferric reducing antioxidant power (FRAP) observed at 6% enrichment. Overall, the results confirm that rosehip powder is a promising functional food ingredient for jelly fortification, with potential health benefits through its antioxidant activity.

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