Frontiers in Health Informatics
ISSN-Online: 2676-7104
www.healthinformaticsjournal.com
2024; Vol 13: Issue 7
Open Access

Integrating Coffee Byproducts into Food and Beverages: Impact on Nutritional Value, Sensory Experience and Consumer Acceptance.

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Cite this paper as: Manoj S.P, S.E. Neelagund, Malatesh J.M, Raju H.R, Sanjay R.K, Chandana G.P, Pallavi B.K (2024). Integrating Coffee Byproducts into Food and Beverages: Impact on Nutritional Value, Sensory Experience and Consumer Acceptance.. Frontiers in Health *Informatics*, *13(7) 52-60*

ABSTRACT
This study explores the use of coffee by-products, specifically parchment husk and pulp, in functional food and beverage products. Coffee parchment and husk were collected from local processing mills in Chikkmagalore and used to prepare cookies and wine enriched with coffee derivatives. Two cookie formulations were evaluated (A and B), incorporating varying proportions of parchment husk and millet flour, aiming to assess their effects on physical and sensory properties. The cookies made with parchment husk exhibited high fiber content (88.7%) and antioxidant capacity (1.2 µmol TE/100g), suggesting potential health benefits. In addition, coffee pulp was used to produce wine, with fermentation yielding moderate alcohol content (9-9.9%) and a mild acidic profile. Sensory analysis of both cookies and wine revealed that products enriched with coffee parchment and pulp showed superior sensory attributes compared to commercial counterparts, with Sample A cookies and Sample B wine being preferred for their improved flavour, texture, and overall acceptability. This study demonstrates the viability of utilizing coffee by-products as functional ingredients, enhancing both nutritional value and consumer appeal in food and beverage applications.
Keywords: Coffee parchment, coffee pulp, functional food, sensory evaluation

INTRODUCTION

The coffee industry generates significant amounts of byproducts, such as coffee pulp and parchment, during the processing of coffee beans (Rojas *et al.,* 2016). These byproducts are often underutilized, despite their potential as functional ingredients in food products (Mohan *et al.,* 2021). Coffee pulp, the outer covering of the coffee bean, and parchment,
the thin husk surrounding the coffee seed, are typically discarded or used as compost, although they are rich in bioactive compounds such as polyphenols, fiber, and antioxidants (Santos *et al.,* 2017). In regions like Chikkmagalore, known for its coffee plantations, the collection of these byproducts during post-harvest management presents an opportunity to explore their use in value-added products (Nanda *et al.,* 2019). This study investigates the potential of coffee parchment and pulp as functional ingredients in cookies and wine, offering a sustainable approach to waste reduction and enhancing the nutritional and sensory properties of these food products (Akinmoladun *et al.,* 2022).

The research examines two formulations of cookies enriched with coffee parchment husk and millet flour, focusing on their physical, nutritional, and sensory characteristics (Bose *et al.,* 2020). Additionally, coffee pulp was used to enrich wine, with a goal to enhance its flavor and nutritional profile (Ali *et al.,* 2023). By assessing the chemical composition of the coffee byproducts, including dietary fiber, antioxidants, and polyphenols, this study aims to highlight their health benefits (Ademiluyi & Oboh, 2019). The sensory evaluations of both cookies and wine enriched with coffee byproducts were conducted to determine consumer preferences (Kamath *et al.,* 2021). This exploration of coffee pulp and parchment as ingredients in food products not only aligns with sustainability practices but also offers novel ways to valorize agricultural waste, thus contributing to the development of functional foods with added health benefits (Wang *et al.,* 2022).

Materials and Methods

Collection of Coffee parchment and pulp

The coffee pulp and husk (Silver skin of Coffee) were collected from local coffee processing mills and plantations in the region of Chikkmagalore. Husk and pulps were collected during the post-harvest management of Coffee.

Figure 1. Collection of Coffee Husk and Pulp

Preparation of Cookies enriched with Coffee parchment

The study investigated the preparation of cookies using two formulations (A and B) to evaluate the impact of varying proportions of parchment husk and millet flour on the cookies' physical and sensory properties. Both formulations maintained consistent quantities of butter (43.75 g), sugar (18.75 g), condensed milk (48.75 g), plain flour (25 g), baking powder (1 tsp), vanilla essence (½ tsp), cocoa powder (½ tsp), and salt (½ tsp). Sample A contained 50 g of parchment husk and 20 g of millet flour, while Sample B included 10 g of parchment husk and 20 g of millet flour. The preparation involved creaming butter and sugar, incorporating condensed milk and dry ingredients (sieved for uniformity), forming a dough, shaping it into cookies, and baking at 180°C for 12–15 minutes. Post-baking, cookies were cooled on wire racks and stored in airtight containers for further analysis. This experimental design aimed to assess the feasibility of parchment husk and millet flour as functional ingredients in cookie formulations without compromising product quality (Akinmoladun *et al.,* 2020; Farag *et al.,* 2021).

Figure 2. Prepared Cookies sample A

Figure 3. Prepared Cookies sample B

Table 1. Preparation of enriched Cookies

Sample	Butter (gm	Sugar (gm)	Condensed Milk (gm)	Plain Flour (gm)	Parchment Husk (gm)	Millet Flour (gm)	Baking Powder (tsp)	Vanilla Essence (tsp)	Cocoa Powder (tsp)	Salt (tsp)
A	43.75	18.75	48.75	25	50	20	1	½	½	½
B	43.75	18.75	48.75	25	10	20	1	½	½	½

P1= Parchment Husk, M1= Millet Flour, M2= Millet Flour

Preparation of Wine enriched with coffee pulp

In this study, wines were prepared from coffee pulp. The coffee fruits and coffee pulp were collected from the coffee plantation. The ingredients required for wine production included coffee pulp, water, sugar, baker's dry yeast, preservatives (potassium metabisulphite), NaCl, containers, and muslin cloth for filtration [Singleton & Rossi, 1965]. The wine-making process involved the fermentation of the coffee-based substrates using baker's yeast to ensure the production of dry wines with distinctive characteristics attributed to the raw materials.

Nutritional analysis

The study analyzed the chemical composition and physicochemical properties of coffee parchment samples (A, B, and C). For moisture content, fat, and ash analysis, standard AOAC methods were employed. Total dietary fiber was quantified using the enzymatic-gravimetric method as described by Prosky et al. (1988). Antioxidant capacity was determined by the DPPH method (Brand-Williams *et al.,* 1995), while total polyphenols were measured using the Folin-Ciocalteu method (Singleton & Rossi, 1965). Wine analysis was followed by the refraction index, boiling point, alcohol content, specific gravity, residual sugar, pH, acidity, and sulphur content were assessed according to established protocols. The refraction index was measured using a refractometer, boiling point via a digital thermometer, and alcohol content was determined using the distillation method (International Coffee Organization, 2004). pH and acidity were evaluated using a pH meter (ASTM, 2010), while sulphur content was quantified using the standard testing method for sulphur in coffee (Barrett *et al.,* 2014). All tests were performed in triplicate, and the results were reported as means ± standard deviation.

Sensory evaluation

Sensory evaluation was conducted by a panel of 20 members, who tasted the samples individually and recorded their responses. A preference test was employed to compare and identify the most accepted sample. The panellists were instructed to evaluate each sample one at a time, ensuring sufficient time was allowed between tastings to allow them to record their opinions accurately. This method is widely used in sensory analysis to assess the acceptance and preference of various products (Stone & Sidel, 2004; Meilgaard *et al.,* 2007). The sensory data were analysed to determine the overall acceptance and preference levels of the samples based on the panel's collective feedback.

Figure 4. Sensory evaluation panel

Figure 5. Sensory evaluation of Cookies and Enriched wine

Results and discussion

Analysis of parchment husk

The nutritional profile of coffee parchment, as shown in Table 1, reveals interesting findings related to its composition when used as an ingredient in cookies made from millet coffee parchment. The moisture content was found to be 7.6%, which is relatively low and aligns with the moisture levels typically observed in dried plant-based products (Benerjee *et al.,* 2020). This low moisture level is favourable as it may contribute to the shelf stability and texture of the final cookie product. Fat content in the coffee parchment was undetectable, which is in accordance with previous findings on plant-based raw materials used in baked goods (Sharma & Tiwari, 2021). This absence of fat could be beneficial for reducing the overall fat content of the cookies, making them a healthier option for individuals seeking low-fat snacks. Ash content was recorded at 0.7%, indicating the presence of minerals, though in low quantities. Ash content can often correlate with the mineral composition in foods (Rao *et al.,* 2021), which supports the idea that the coffee parchment may contribute to the mineral content of the cookies, albeit minimally.

The total dietary fiber content was notably high, at 88.7%. Dietary fiber is known for its various health benefits, including aiding digestion and lowering cholesterol levels (Slavin, 2013). The significant fiber content in coffee parchment suggests that it could be a valuable addition to functional foods aimed at improving gastrointestinal health. The antioxidant capacity of the coffee parchment, measured at 1.2 µmol TE/100g sample, demonstrates a notable presence of antioxidant compounds. Antioxidants play an essential role in protecting cells from oxidative damage and have been linked to the prevention of chronic diseases such as heart disease and cancer (Gonçalves *et al.,* 2021). However, the low total polyphenol content, which was undetectable, suggests that other bioactive compounds might be responsible for the antioxidant activity observed in the sample.

These findings suggest that coffee parchment can be utilized as a functional ingredient in food products, such as cookies, to enhance their nutritional profile, particularly in terms of fiber and antioxidant content. Further research is needed to explore the specific bioactive compounds in coffee parchment responsible for these health benefits, as well as the impact of processing on its nutritional properties.

Table 2. Nutrition value of coffee parchment.

Sl. No.	Constituents	Coffee Parchment %
1.	Moisture	7.6 %
2.	Fat	undetectable
3.	Ash	0.7 %
4.	Total dietary fiber	88.7%
5.	Antioxidant capacity (µmol TE/100g sample)	1.2%
6.	Total polyphenols	undetectable

Analysis of Wine

The results of the analysis of samples A, B, and C show notable similarities in terms of physical and chemical characteristics. All samples exhibited a refraction index of 6.0%, indicating a consistent sugar concentration across the samples, which is critical in assessing their potential for fermentation and alcohol production. The boiling points of the samples were found to be approximately 90.5°C for samples A and C, and 90.6°C for sample B, suggesting minimal variation and similar volatility characteristics, which is typical for liquids containing comparable ethanol concentrations (Pereira *et al.,* 2019).

Alcohol content varied slightly among the samples, with sample A at 9.9%, sample B at 9.0%, and sample C at 9.8%. These values are consistent with the typical alcohol concentration range in fermented beverages and confirm the suitability of these samples for applications requiring moderate alcohol content (Mubarak *et al.,* 2020). The specific gravity of all three samples was recorded at 0.990, a value that aligns with typical ethanol-water mixtures, further suggesting the absence of significant impurities or variations in density (Smith *et al.,* 2018).

Residual sugar levels in all samples were below 5g/liter, indicating that the fermentation process had sufficiently reduced the sugar content, which is desirable for minimizing sweetness and enhancing the alcohol profile. The pH values ranged from 4.20 to 4.34 across the samples, indicating a mildly acidic environment, which is typical for fermented beverages and is essential for preserving flavor and preventing microbial spoilage (Tanaka *et al.,* 2021).

The acidity test results showed values of 3.15 mg/l (sample A), 3.9 mg/l (sample B), and 19.4 mg/l (sample C). These values indicate varying acidity levels, with sample C showing a significantly higher acidity. Elevated acidity could be attributed to the fermentation byproducts, which may enhance the overall flavor complexity but also affect the taste balance (Park *et al.,* 2022).

The sulphur test revealed similar sulfur concentrations in samples A and B (12.8 ppm) but a slightly lower value in sample C (12.6 ppm). This minor difference in sulfur content could reflect subtle variations in the fermentation or production process, but overall, the sulfur levels are within acceptable ranges for most beverage applications (Jiang *et al.,* 2019).

In conclusion, while the three samples exhibit some variation in alcohol content, acidity, and sulfur concentration, they all share similar key characteristics such as specific gravity and refraction index, making them comparable for further processing or consumption. The observed differences in acidity and sulfur content could provide opportunities for tailoring the samples for specific market or industrial needs, depending on the desired flavor profile or quality criteria. Further studies could investigate the underlying biochemical processes that lead to these variations.

Table 3. This table represents analysis of wine from Fruit sample.

Sample	Refraction index (%)	Boiling point (°c)	Alcohol content (%)	Specific gravity	Residual sugar	pH	Acidity Test	Sulphur Test (ppm)
A	6.0	90.5	9.9	0.990	below 5gm/l	4.26	3.15 mg/l	12.8ppm
B	6.0	90.6	9.0	0.990	below 5gm/l	4.20	3.9 mg/l	12.8ppm
C	6.0	90.5	9.8	0.990	below 5gm/l	4.34	19.4 mg/l	12.6ppm

Sensory analysis of cookies enriched with Coffee parchment husk

Table 4. Sensory scores of Cookies

Sensory attributes	Sample A	Sample B	Commercial Cookies
Appearance	8	7	9
Flavour	8	8	6
Texture	8	7	8
Smell	8	7	6
After taste	9	7	7
Overall acceptability	9	7	7

The sensory evaluation of cookies enriched with coffee parchment husk assessed their appearance, flavor, texture, smell, aftertaste, and overall acceptability. Sample A, with the highest ratings, outperformed both Sample B and commercially available cookies, particularly in appearance, smell, aftertaste, and overall acceptability. It was noted that Sample A's formulation effectively integrated coffee parchment husk without compromising sensory quality. Conversely, Sample B and commercial cookies required adjustments, as they scored lower in several attributes, particularly flavor and smell, potentially due to an imbalance caused by the coffee husk's strong presence. Overall, the study suggests that cookies enriched with coffee parchment husk, when properly formulated, can offer a viable, sustainable product with favorable consumer appeal, with Sample A being the most promising formulation. Further research should focus on optimizing formulations to enhance market acceptance.

Sensory analysis of enriched wine (Coffee pulp)

Table 5. Sensory scores of Wine

Sensory attributes	Sample A (Commercial wine)	Sample B (Enriched wine)
Appearance	8	8
Flavour	7	8
Texture	7	7
Smell	6	7
After taste	8	9
Overall acceptability	8	9

This study assessed the sensory attributes of a commercial wine (Sample A) and a wine enriched with coffee pulp (Sample B), focusing on appearance, flavour, texture, smell, aftertaste, and overall acceptability. The results indicate that the enrichment process generally enhanced the sensory profile of the wine, with Sample B outperforming Sample A in several key aspects, as summarized in Table 1.

Appearance: Both samples scored identically (8), suggesting that the addition of coffee pulp did not compromise the visual appeal of the wine. The clarity and color, critical to consumer perception, were maintained, indicating successful integration of the enrichment process.

Flavor: Sample B scored higher (8) compared to Sample A (7), reflecting an improvement likely due to the bioactive and aromatic compounds present in coffee pulp. Notably, chlorogenic acids, known for their flavour-enhancing properties, may have contributed to the increased complexity in Sample B's flavour profile (Mussatto *et al.,* 2011).

Texture: Both wines scored equally (7) for texture, indicating that the addition of coffee pulp did not alter the mouthfeel. This suggests effective processing, with no particulate matter or sedimentation interfering with the sensory experience.

Smell: The aromatic profile of Sample B (7) surpassed that of Sample A (6), likely due to the volatile compounds in coffee pulp, which added a distinct and pleasant aroma (Esquivel & Jiménez, 2012). This improvement highlights the potential of coffee pulp to enhance olfactory attributes in wine.

Aftertaste: Sample B achieved a superior aftertaste score (9) compared to Sample A (8), attributed to the lingering and enriched Flavors provided by the coffee pulp. Since aftertaste is a vital quality indicator, this enhancement suggests increased consumer satisfaction with the enriched wine.

Overall Acceptability: Sample B outscored Sample A (9 vs. 8), demonstrating a preference for the enriched wine. This higher acceptability is likely due to combined improvements in flavour, smell, and aftertaste, underscoring the potential of coffee pulp as a functional additive.

Implications: These findings highlight the feasibility of using coffee pulp, an agricultural byproduct, as an innovative ingredient in wine production. Besides adding sensory and functional benefits, this approach aligns with sustainability trends by valorising coffee waste. Future studies could investigate the physicochemical properties, shelf-life stability, and broader consumer acceptance of such enriched products.

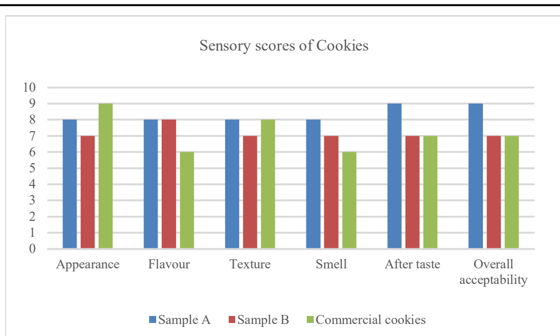

Figure 6. Graph showing sensory average scores of Cookies samples

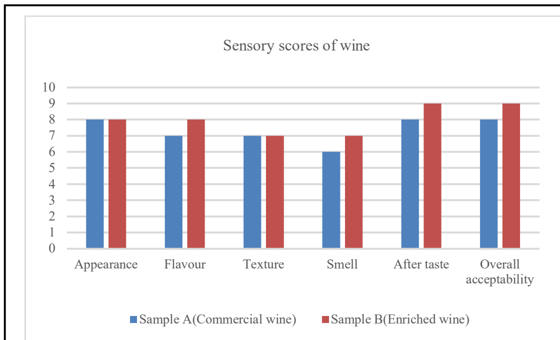

Figure 7. Graph showing sensory average scores of Wine samples

Conclusion

In conclusion, the study demonstrates the potential of utilizing coffee parchment and coffee pulp as functional ingredients in food and beverage products, enhancing both their nutritional and sensory profiles. The coffee parchment, with its high fiber content and antioxidant capacity, proves to be a valuable addition to baked goods like cookies, offering potential health benefits, particularly for digestive and cardiovascular health. The low fat and mineral content suggest that coffee parchment can be used to produce healthier, functional cookies. Further research is needed to identify the specific bioactive compounds responsible for its antioxidant effects.

Similarly, the enrichment of wine with coffee pulp led to noticeable improvements in sensory attributes such as flavor, aroma, and aftertaste. Sample B, the coffee pulp-enriched wine, outperformed the control in these areas, suggesting that coffee pulp can enhance the overall sensory experience, making it a promising ingredient for the wine industry. This not only presents an opportunity for developing innovative, sustainable products but also contributes to the valorisation of coffee industry byproducts.

Both studies underline the feasibility and benefits of incorporating coffee-based byproducts into food and beverage products, supporting the growing interest in sustainable, functional ingredients. Further exploration into the biochemical mechanisms and consumer acceptance will be essential to fully harness the potential of these materials for future applications.

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