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BIOACTIVE COMPOUNDS, ANTIOXIDANT, AND ANTIMICROBIAL ACTIVITIES OF GREEN COFFEE BEAN, ROASTED, SPENT, AND SILVER SKIN COFFEE

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I. INTRODUCTION

Lipid oxidation and microbial growth are two primary factors contributing to the deterioration of meat and meat products, leading to significant economic losses estimated at up to USD 150 billion due to high perishability [1]. In the food industry, synthetic antioxidants, such as nitrites, are widely used to combat pathogenic bacteria and reduce lipid oxidation. However, these additives have been found to exhibit carcinogenic properties [2]. Consequently, the industry seeks natural alternatives to replace synthetic compounds [3]. Agro-industrial waste, such as spent coffee grounds and coffee silver skin, presents a potential solution [4]. Furthermore, approximately 20% of green coffee beans are discarded due to quality standards [3]. Since coffee and its derivatives contain high levels of phenolic compounds and possess antimicrobial properties, this study aims to compare the bioactive compound content, antioxidant capacity, and antimicrobial activity of green coffee and its by-products.

II. MATERIALS AND METHODS

Green coffee beans, roasted coffee, silver skin, and spent coffee were ground to an 80-mesh particle size. Extracts were obtained using a water-ethanol mixture (1:1) and ultrasound-assisted extraction (42 kHz, 25°C, 30 min). The extracts were evaluated for total phenols, flavonoids, chlorogenic acid, and condensed tannins. Antioxidant activity was measured using ABTS assay (radical cation inhibition), DPPH assay (free radical inhibition), and Reducing power methods (Prussian blue and FRAP assays). Antimicrobial activity was assessed using the broth microdilution method [5]. Data were analyzed using GLM analysis of variance, and treatment means were compared using the Tukey-Kramer test at a 5% significance level.

III. RESULTS AND DISCUSSION

About their phytochemical composition, the spent coffee extract exhibited the highest levels ($p<0.05$) of total phenols, flavonoids, and condensed tannins. In contrast, green coffee extract contained the highest concentration of chlorogenic acid, a key compound known for its potent antioxidant properties (Table 1).

Table 1 – Comparison of the phytochemical compounds of green coffee extracts and by-products.

Treatment	Phenols (mg gallic acid eq./g)	Flavonoids (mg quercetin eq./g)	Chlorogenic acid (mg chlorogenic acid eq./g)	Condensed tannins (mg catechin eq./g)
T1	395.68±19.76^{a}	56.79±3.84^{b}	372.7 ± 5.36^{a}	245.66 ± 8.88^{b}
T2	608.91±24.45^{b}	72.19±6.54^{c}	1283.0 ± 14.49^{b}	267.50 ± 13.16^{b}
T3	662.62±26.28^{c}	166.04±10.67^{d}	1888.1 ± 20.98^{c}	849.83 ± 48.69^{c}
T4	638.83±36.02^{b}	38.10±5.75^{a}	2110.2±14.09^{d}	75.44 ± 6.16^{a}

T1: Silver skin; T2: Roasted coffee; T3: Spent coffee; T4: Green coffee beans

Concerning antioxidant activity, all extracts demonstrated significant antioxidant activity (Table 2). Silver skin and spent coffee extracts showed the highest ($p<0.05$) antiradical activity against ABTS, while roasted and green coffee extracts exhibited the most vigorous DPPH scavenging activity. As measured by FRAP, the reducing power was highest in roasted and spent coffee extracts, though the difference was insignificant ($p>0.05$).

Table 2 – Comparison of the antioxidant activity of green coffee and by-products.

Treatment	ABTS (% Inhibition)	DPPH (% Inhibition)	Reducing power (Abs700nm)	FRAP (mg Fe^{2+}/g)
T1	91.61 ± 0.18b^{c}	73.15 ± 2.08^{a}	0.107 ± 0.00^{a}	396.19 ± 48.35^{a}
T2	92.07 ± 0.39^{c}	85.18 ± 0.73^{c}	0.7419 ± 0.01^{d}	652.84± 21.23^{d}
T3	87.99 ± 0.66^{a}	76.8 ± 0.84^{b}	0.7316 ± 0.04^{d}	626.42± 17.09^{d}
T4	91.50 ± 0.36^{b}	84.87 ± 0.76^{c}	0.5756 ± 0.01^{c}	572.94 ± 6.56^{c}
Std.	92.89 ± 0.26^{d}	93.41 ± 0.34^{d}	0.2596 ± 0.00^{b}	451.13± 29.49^{b}

T1: Silver skin; T2: Roasted coffee; T3: Spent coffee; T4: Green coffee beans; Std.: Positive control (ascorbic acid)

Green coffee exhibited the highest antimicrobial activity ($p<0.05$) against all tested strains, similar to the positive control (gentamicin). However, silver skin and roasted coffee extracts displayed comparable activity ($p>0.05$) to green coffee and gentamicin against *L. monocytogenes*, *E. coli* O157:H7, and *S. typhimurium* (Table 3).

Table 3 – Comparison of the antimicrobial activity of green coffee and by-products.

Treatment	*S. aureus* (O.D. 620 nm)	*L. monocytogenes* (O.D. 620 nm)	*E. coli O157:H7* (O.D. 620 nm)	*S. typhimurium* (O.D. 620 nm)
T1	0.119 ± 0.00^{b}	0.116 ± 0.01^{a}	0.158 ± 0.00^{a}	0.188 ± 0.03^{a}
T2	0.126 ± 0.00^{b}	0.116 ± 0.01^{a}	0.170 ± 0.00^{a}	0.178 ± 0.01^{a}
T3	0.213 ± 0.01^{c}	0.193 ± 0.03^{b}	0.261 ± 0.01^{b}	0.256 ± 0.01^{b}
T4	0.100 ± 0.01^{a}	0.088 ± 0.02^{a}	0.149 ± 0.01^{a}	0.161 ± 0.02^{a}
NC	0.149 ± 0.01^{c}	0.181 ± 0.03^{c}	0.582 ± 0.04^{c}	0.770 ± 0.05^{c}
Std.	0.089 ± 0.00^{a}	0.107 ± 0.00^{a}	0.178 ± 0.02^{a}	0.167 ± 0.01^{a}

T1: Silver skin; T2: Roasted coffee; T3: Spent coffee; T4: Green coffee beans; NC: Negative control (BHI solution); Std.: Positive control (gentamicin)

Synthetic antioxidants like ascorbic acid and artificial antimicrobials are widely used in food production. However, prolonged use of synthetic antibiotics can lead to antimicrobial resistance, posing health risks. Therefore, natural antioxidants and antimicrobials from coffee by-products could be safer alternatives [2,3].

IV. CONCLUSION

The results indicate that green coffee extracts and by-products can be utilized as natural ingredients to enhance meat products' antioxidant and antimicrobial properties, offering a viable alternative to synthetic additives.

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