

Nutritional Composition and Antioxidant Properties of White Pepper (*Piper Nigrum* L.)

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Abstract

White pepper (*Piper nigrum* L.) is a widely used culinary spice containing nutritional and phytochemical constituents of potential relevance to food applications. The present laboratory-based study evaluated the proximate composition, selected mineral content, and antioxidant characteristics of white pepper powder. Moisture, ash, crude fibre, fat, protein, and carbohydrate contents were determined using conventional analytical procedures. Calcium and iron were estimated using titrimetric and colorimetric methods, respectively. An aqueous extract was evaluated for antioxidant activity using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging assay, total phenolic content, and total flavonoid content. The reported proximate composition of white pepper powder was 3.0 ± 0.25 g/100 g moisture, 0.4 ± 0.07 g/100 g protein, 6.3 ± 5.12 g/100 g ash, 1.4 ± 0.83 g/100 g fat, 5.6 ± 1.39 g/100 g crude fibre, and 83.8 ± 0.67 g/100 g carbohydrate. Calcium and iron contents were reported as 10.1 ± 0.99 and 25.1 ± 0.05 mg/100 g, respectively. DPPH radical-scavenging activity increased progressively across the reported concentration range, reaching 75.77% at the highest tested concentration. Total phenolic content was reported as 4.6 ± 0.2 , although an inconsistency in the unit of expression was identified in the source dataset. Total flavonoid content was reported as 0.1 ± 0.02 mg quercetin equivalents/100 g. The findings indicate that the tested white pepper sample was carbohydrate-rich and exhibited concentration-dependent DPPH radical-scavenging activity. However, inconsistencies in selected analytical units and incomplete methodological documentation limit direct comparison with other studies.

Keywords: antioxidant activity; DPPH; mineral composition; nutritional composition; *Piper nigrum*; white pepper

1. Introduction

Spices are important components of food systems because they contribute desirable sensory characteristics, including flavour, aroma, and pungency, while also providing a range of nutritional and phytochemical constituents (Salehi et al., 2019). Among the commercially important spices, *Piper nigrum* L. occupies a prominent position and is extensively used in culinary applications worldwide (Takooree et al., 2019). White pepper is obtained from mature berries of *P. nigrum* after removal of the outer pericarp, leaving the dried seed as the principal commercial product. Differences in processing distinguish white pepper from black pepper and may influence its sensory, chemical, and functional characteristics (Adiani et al., 2020). The chemical composition of pepper may vary according to several factors, including cultivar, geographical origin, maturity, postharvest processing, storage conditions, and analytical methodology. Such variation is particularly relevant when interpreting nutritional and antioxidant data because

processing and extraction procedures can influence the chemical constituents recovered and measured in laboratory analyses (Michiels et al., 2012).

Piper species contain diverse secondary metabolites and volatile constituents, and *P. nigrum* has received considerable scientific attention because of its culinary importance and phytochemical complexity (Dhanya et al., 2021). Pepper is particularly associated with piperine and other bioactive constituents, in addition to volatile compounds and other phytochemicals that may contribute to its chemical and functional properties (Ahmad et al., 2012).

The antioxidant potential of pepper and other *Piper* species has been investigated using several in vitro analytical approaches. Among these methods, the DPPH radical-scavenging assay is widely used to evaluate the ability of compounds or extracts to reduce a stable free radical. However, antioxidant results can vary substantially according to sample characteristics, extraction conditions, solvent selection, concentration, and the analytical method employed. Therefore, direct comparison of results between studies requires careful consideration of methodological differences.

The nutritional composition of white pepper is also relevant from a food science perspective. Proximate analysis provides information regarding moisture, protein, fat, ash, crude fibre, and carbohydrate, whereas mineral analysis contributes additional information regarding the micronutrient composition of a specific sample (Emmanuel-Ikpeme et al., 2014). However, compositional values should be interpreted cautiously because the nutritional characteristics of plant-derived food materials may differ according to biological and environmental factors as well as processing conditions.

Despite the widespread culinary use of white pepper, variations in sample origin, processing, extraction methods, and analytical procedures can complicate comparisons of nutritional and antioxidant characteristics among studies (Agbor et al., 2006). Therefore, the present study was undertaken to evaluate the proximate composition, selected mineral content, and antioxidant characteristics of a white pepper powder sample.

The specific objectives were:

1. To determine the proximate composition of white pepper powder.
2. To estimate the calcium and iron contents of the sample.
3. To evaluate concentration-dependent DPPH radical-scavenging activity.
4. To determine the reported total phenolic and total flavonoid contents of the aqueous white pepper extract.

2. Materials and Methods

2.1 Study material

White pepper (*Piper nigrum* L.) was used as the study material. White pepper is commercially produced from mature pepper berries through processing procedures that remove the pericarp and retain the seed (Liu et al., 2018).

2.2 Proximate composition

The proximate composition of white pepper powder was evaluated using the analytical procedures specified in the original study. Moisture content was determined using the hot-air-oven method, ash content using dry ashing, crude fibre using an acid-alkali procedure, fat using a Soxhlet extraction method, and protein using the micro-Kjeldahl method.

Carbohydrate content was calculated by difference according to the following equation:

$$\text{Carbohydrate (g/100 g)} = 100 - (\text{moisture} + \text{protein} + \text{fat} + \text{ash} + \text{crude fibre})$$

2.3 Mineral analysis

Calcium content was estimated using a titrimetric method, while iron content was estimated using Wong's colorimetric method. The original analytical description indicates that ferric ions formed a coloured complex with potassium thiocyanate, with absorbance measured at 540 nm.

2.4 Preparation of aqueous extract

The original experimental plan specified the preparation of an aqueous extract for antioxidant evaluation. Extraction conditions can substantially influence the recovery of phytochemicals and the antioxidant activity subsequently measured in plant-derived materials (Lloki-Assanga et al., 2015).

2.5 DPPH radical-scavenging activity

Antioxidant activity was evaluated using the DPPH radical-scavenging assay. This assay is commonly used to assess the ability of antioxidant compounds to reduce a stable free radical and is frequently applied in the evaluation of plant-derived extracts and food materials (Mishra et al., 2012).

The white pepper sample and L-ascorbic acid standard were evaluated across the reported concentration range of 0–1.0. Because the dissertation did not clearly specify the unit associated with these concentrations, the concentration values are presented without assigning an unsupported unit.

The approximate concentration required to produce 50% radical scavenging by the white pepper sample was retrospectively estimated by linear interpolation between the two experimentally reported concentrations surrounding the 50% response. This value is presented as a mathematical approximation and not as an experimentally determined IC_{50} .

2.6 Total phenolic content

Total phenolic content was determined using gallic acid as the reference standard. The reported standard curve equation was:

$$y = 0.0024x + 0.0456$$

with a reported coefficient of determination of:

$$R^2 = 0.9982$$

Phenolic compounds are frequently investigated in plant-derived foods because of their chemical properties and potential contribution to antioxidant activity. The results table expresses the value as mg gallic acid equivalents (GAE)/100 g.

2.7 Total flavonoid content

Total flavonoid content was measured using an aluminium chloride-based procedure and expressed in terms of quercetin equivalents (QE). Flavonoids represent an important class of plant-derived phenolic compounds that may contribute to the antioxidant characteristics of botanical materials.

2.8 Statistical analysis

Results in the original dataset were presented as mean $\pm$ standard deviation.

3. Results

3.1 Proximate composition of white pepper powder

The reported proximate composition of the analysed white pepper powder is presented in Table 1.

Table 1. Reported proximate composition of white pepper powder

Component	Mean $\pm$ SD (g/100 g)
Moisture	3.0 $\pm$ 0.25
Protein	0.4 $\pm$ 0.07
Ash	6.3 $\pm$ 5.12

Fat	1.4 ± 0.83
Crude fibre	5.6 ± 1.39
Carbohydrate	83.8 ± 0.67

The highest reported component was carbohydrate, followed by ash and crude fibre. Moisture and fat contents were relatively low, while protein represented the smallest reported proximate component.

A quantitative reconstruction of the carbohydrate calculation was performed using the individual mean values reported in Table 1:

$$100 - (3.0 + 0.4 + 6.3 + 1.4 + 5.6) = 83.3 \text{ g/100 g}$$

Thus, the reconstructed value differs by 0.5 g/100 g from the dissertation-reported carbohydrate value of 83.8 g/100 g.

3.2 Mineral composition

The reported calcium and iron contents are presented in Table 2.

Table 2. Reported mineral composition of white pepper powder

Mineral	Mean ± SD (mg/100 g)
Calcium	10.1 ± 0.99
Iron	25.1 ± 0.05

Iron was reported at a higher concentration than calcium in the analysed sample.

3.3 DPPH radical-scavenging activity

The DPPH radical-scavenging activity of the white pepper sample and L-ascorbic acid standard is presented in Table 3.

Table 3. DPPH radical-scavenging activity of white pepper sample and L-ascorbic acid

Reported concentration*	L-Ascorbic acid scavenging (%)	White pepper sample scavenging (%)
0.0	0.00	0.00
0.1	82.40	5.45
0.2	85.50	23.15
0.3	88.70	33.33
0.4	90.30	35.01
0.5	90.70	47.47
0.6	92.40	60.81
0.7	93.80	63.03
0.8	94.20	66.23
0.9	95.20	75.15
1.0	97.03	75.77

The white pepper sample demonstrated an increasing DPPH radical-scavenging response across the reported concentration range. Scavenging activity increased from 5.45% at a reported concentration of 0.1 to 75.77% at the reported concentration of 1.0.

The approximate 50% scavenging point occurred between concentrations of 0.5 and 0.6. Linear interpolation produced an estimated concentration of approximately **0.519 concentration units**.

The L-ascorbic acid standard demonstrated greater scavenging activity than the white pepper sample at every corresponding reported concentration.

3.4 Total phenolic content

The original study reported a total phenolic content of: 4.6 ± 0.2

Phenolic compounds are commonly evaluated as contributors to the antioxidant characteristics of plant-derived materials, although the magnitude of reported values depends on the extraction and analytical procedures employed (Dai et al., 2010).

3.5 Total flavonoid content

The total flavonoid content of the white pepper aqueous extract was reported as: 0.1 ± 0.02 mg QE/100 g. Flavonoids and other phytochemical constituents may contribute to the antioxidant characteristics observed in *Piper* species, although their measured concentrations can vary according to sample composition and analytical methodology.

4. Discussion

The present study provides a laboratory-based nutritional and antioxidant profile of a white pepper sample. The most prominent feature of the reported proximate composition was the high carbohydrate content, which accounted for more than four-fifths of the sample on the reported analytical basis. The relatively low moisture content is consistent with the general characteristics expected of dried spice materials and may be relevant to their storage stability.

Nevertheless, the quantitative reconstruction identified a discrepancy in the carbohydrate calculation. The original analytical method specified carbohydrate determination by difference. When the reported mean values for moisture, protein, fat, ash, and crude fibre were substituted into the stated equation, the calculated carbohydrate content was 83.3 g/100 g rather than the reported 83.8 g/100 g. The difference is relatively small but should not be ignored in a scientific publication. It may result from the use of unrounded values during the original calculation, although this explanation cannot be verified without access to the raw analytical data.

The reported ash value of 6.3 ± 5.12 g/100 g also requires cautious interpretation because the standard deviation is unusually large relative to the mean. Such variability may reflect substantial analytical variation, transcription error, or a small number of replicates. The available dataset does not permit determination of the underlying cause. Therefore, future analyses should report individual replicate values and the number of observations.

The mineral analysis indicated measurable concentrations of calcium and iron. Mineral concentrations in plant-derived food materials may vary according to cultivation conditions, geographical origin, sample processing, and analytical methodology. Consequently, the present values should be interpreted as characteristics of the specific analysed sample rather than universal compositional standards for white pepper.

The antioxidant findings demonstrated a concentration-dependent increase in DPPH radical-scavenging activity. At the highest reported concentration, the white pepper sample achieved 75.77% scavenging, indicating measurable in vitro radical-scavenging capacity under the conditions of the experiment. However, the L-ascorbic acid standard consistently demonstrated higher activity at corresponding concentrations.

The approximate 50% scavenging concentration was reconstructed at approximately 0.519 concentration units by interpolation between the experimentally reported 0.5 and 0.6 concentration levels. This reconstruction should be regarded only as a descriptive mathematical estimate because the concentration unit was not documented and no experimentally determined IC_{50} was reported. Future investigations

should report concentration units explicitly and determine IC_{50} values using appropriately designed concentration-response analyses.

The observed antioxidant activity is consistent with the broader scientific interest in the phytochemical and antioxidant properties of *Piper* species (Salehi et al., 2019). Nevertheless, antioxidant activity cannot be attributed to a specific compound or group of compounds on the basis of the present data because detailed phytochemical characterization was not performed.

The total phenolic content of the sample was reported as 4.6 ± 0.2 , but the inconsistency between mg GAE/100 g and mg GAE/g extract represents a significant limitation. These units are not interchangeable because they represent fundamentally different reporting bases. Consequently, a definitive comparison of the present phenolic value with values reported in other studies would be scientifically inappropriate until the original analytical records establish the correct unit.

Similarly, the reported total flavonoid content of 0.1 ± 0.02 mg QE/100 g should be interpreted cautiously because complete details regarding extraction yield and the precise analytical basis were not available for retrospective verification. Such methodological details are particularly important because phytochemical measurements can vary substantially with extraction and analytical conditions.

The findings collectively suggest that the analysed white pepper sample possesses measurable antioxidant activity and contains nutritional and mineral constituents of interest. White pepper production and processing can influence the characteristics of the final spice product, which should be considered when comparing the present findings with those obtained from other white pepper samples.

Importantly, the observed in vitro antioxidant activity should not be interpreted as evidence of therapeutic efficacy or clinical disease prevention. In vitro assays provide information regarding chemical activity under controlled experimental conditions and cannot independently establish physiological or clinical effects in humans.

5. Conclusion

The present study evaluated the nutritional composition, selected mineral content, and antioxidant characteristics of white pepper (*Piper nigrum* L.). The analysed sample was reported to contain a high carbohydrate content together with measurable amounts of crude fibre, ash, calcium, and iron. The aqueous extract demonstrated concentration-dependent DPPH radical-scavenging activity, reaching 75.77% scavenging at the highest reported concentration.

The study also reported measurable total phenolic and flavonoid contents. However, retrospective quantitative verification identified inconsistencies in the carbohydrate calculation and total phenolic reporting unit, while several methodological details required for complete reproducibility were unavailable.

Therefore, the findings support the conclusion that the investigated white pepper sample possesses measurable nutritional and in vitro antioxidant characteristics.

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