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Nutritional and Antioxidant Profile of Finger Millet-Based Composite Flour Biscuits

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ABSTRACT

Finger millet is often proposed as a partial replacement for refined wheat flour in biscuits, on the grounds that it is rich in fibre, calcium and phenolic compounds with antioxidant activity. This narrative review asks what a defensible nutritional and antioxidant profile of a finger millet composite-flour biscuit would look like, using published work on millet composition, cereal phenolics, mineral availability, antioxidant assays and the science of biscuit making. It reports no new data and no biscuits were analysed by the authors. A biscuit made with a share of finger millet flour is likely to be richer in fibre, calcium and phenolics than a refined-wheat equivalent, but the size of the difference depends on the proportion of millet, whether the bran is retained and the variety used. Phytate and tannins reduce how much of the mineral content is absorbed, and antioxidant values from test-tube assays differ with method and extraction and do not translate directly into benefit for consumers. Baking can lower, preserve or release phenolics, and also forms acrylamide, so raw-grain figures cannot stand in for the finished product. Claims about diabetes and health are better described as promising than proven. The review closes with the measurements a decisive study of the baked biscuit should contain.

Keywords: Finger millet; Composite flour; Biscuits; Antioxidant capacity; Phenolic compounds; Mineral bioavailability; Narrative review

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Article Class: Narrative Review

1. Introduction

Biscuits are among the most widely eaten baked snacks in the world. They keep for months, travel well, are cheap and are accepted across age groups, which is exactly why nutrition scientists keep returning to them as a vehicle for

improving what people eat (1, 2). The usual biscuit is refined wheat flour, sugar and fat, and it supplies energy with little else; replacing part of the flour with a more nutritious cereal is the simplest way to change that. Because such snacks are eaten daily, even small compositional shifts



reach many people.

Finger millet (*Eleusine coracana*), known as ragi in much of India and as wimbi in East Africa, is a strong candidate. It is grown on poor soil with little water and has been reviewed repeatedly for its mineral and fibre content (3, 4). It also carries a high load of phenolic compounds in the seed coat, which have drawn attention for their antioxidant behaviour in the laboratory (5, 6).

The title of this article promises a nutritional and antioxidant profile of composite-flour biscuits, and a reader might expect a table of measured values. There is none. No biscuits were made or analysed by the authors, and no local or experimental data are reported. Instead, this narrative review gathers what is already published on finger millet, on its phenolics and its minerals, and on the way baking and formulation change them, and asks what a defensible profile of such a biscuit would look like. Where work on finger millet biscuits is thin, we say so and draw on related cereals. A reader weighing a biscuit claim needs the answer to a plain question: what exactly was in the flour, and what happened to it in the oven?

2. Literature Review

2.1 Finger Millet as a Grain

Finger millet is usually eaten as a whole-meal flour, because the seed coat is thin and tightly bound to the kernel and is not easily separated. Studies of decorticated grain showed that the bran fraction is richer in fibre, minerals and phenolics than the endosperm, and that removing it changes both the appearance and the functional properties of the flour (7). Broad surveys of millets describe a grain that is comparable to other cereals in energy and protein, notable for fibre, and unusually rich in calcium (4, 8) (Table 1). Composition is not constant, though:

variety, growing conditions and milling shift the numbers, which is why tables for the same grain can disagree (3). This is why the same grain can look impressive in one report and ordinary in the next.

2.2 Phenolics and Antioxidant Behaviour

The phenolic compounds of finger millet are concentrated in the seed coat and include phenolic acids and flavonoids, with tannin-like compounds present in some varieties (10, 11). Extracts of the seed coat have shown antioxidant activity in several chemical assays and have inhibited carbohydrate-digesting enzymes and aldose reductase in vitro (12, 13). Much of the phenolic content of millets is bound to cell wall material and is not extracted by simple solvents (6, 14).

Table 1. Finger millet compared with refined wheat flour in general terms.

Attribute	Finger millet (whole-meal)	Refined wheat flour
Dietary fibre	High, mostly in the seed coat (4, 7)	Low, bran removed
Calcium	Notably high for a cereal (8)	Low
Phenolics	Abundant, free and bound (5, 6)	Few
Gluten network	Absent	Present, shapes dough
Antinutrients	Phytate and tannins (9)	Less phytate once milled

Note: Qualitative comparison from the cited reviews. Values vary with variety, milling and fraction, so no figures are given.

In vitro activity is not the same as benefit in a person. One animal study reported better antioxidant status and glycaemic indices in diabetic rats fed millets (15), and the wider grain literature argues that whole grains deliver a complex mixture of bound and free phytochemicals whose combined effect may exceed any single compound (16, 17). These are leads, not evidence that a biscuit containing some finger millet flour will change anything measurable in a



consumer. Small shifts of this kind rarely matter alone, yet they add up across a formulation.

2.3 Minerals, Phytate and Tannins

The mineral story has a catch. Cereals store phosphorus as phytate, which binds iron, zinc and calcium in the gut and reduces how much of each is absorbed, and tannins can do the same (9, 18). A flour can therefore be rich in a mineral on paper and still disappointing nutritionally. The same constraint applies to protein, since interactions between polyphenols and proteins have been shown in sorghum to lower digestibility (19).

Traditional household processing offers a partial answer. Soaking, germination and fermentation lower phytate and can improve the accessibility of minerals (20, 21), and studies on millet and on cereals and legumes in general have measured such changes (22, 23). Baking itself does little to remove phytate, so the question is whether the millet was pretreated before milling. A flour that has been soaked, malted or fermented behaves differently from one that has not.

2.4 What Baking and Formulation Do

A biscuit is a low-moisture, high-sugar, high-fat system, and the roles of its ingredients are well mapped. Sugar and fat control spread, texture and snap, and the gluten network is deliberately kept weak (24, 25). Because a biscuit relies less on gluten than bread does, it tolerates a fair proportion of non-wheat flour, though dough handling and texture change as the proportion rises (2, 26).

3. Materials and Methods

3.1 Scope and Question

The review asks two linked questions. What do published sources say a finger millet composite biscuit can plausibly offer in nutrients and antioxidants, and how

much of that survives milling, dough making and baking? They were split into the components a laboratory study would have to address: flour composition, phenolics, mineral availability, and effects of baking and storage.

3.2 Literature Assembly

The review draws on peer-reviewed articles in four areas: finger millet and millet composition; cereal phenolics and antioxidant methods; mineral bioavailability; and the science of biscuit and cookie making. Sources were chosen by the authors for relevance, starting from the reference lists of major reviews. We did not run a formal systematic search, no database protocol was registered, and no claim of completeness is made. This is a narrative synthesis, restricted to work published in or before the year of this issue, with related studies on other cereals identified as such. Reviews of this sort are more useful when they say where the evidence stops than when they smooth the gap over.

3.3 Appraisal Framework

To decide how far a reported result can be trusted, each source was read against a short set of questions (Table 2). Is the material described well enough to be reproduced? Is the assay one that measures what the authors say it does (27, 28)? Was the sample baked or only milled? Are minerals reported as total content or as something closer to absorbable amounts? No scoring was applied. Asking them is a habit worth keeping even when the answer seems obvious.

4. Results

4.1 What a Finger Millet Biscuit Could Offer

Putting the literature side by side (Figure 1), a composite biscuit with finger millet flour could plausibly carry more



fibre and more calcium than its refined-wheat equivalent, simply because the grain is richer in both (3, 8). It could also carry more phenolic compounds, mostly from the seed coat, as well as some contribution from bound forms (5, 6). How much more depends on the share of millet flour, on whether the flour is whole-meal or decorticated, and on the variety (7).

Table 2. Appraisal questions applied to each source.

Question	Why it matters	Example
Flour described?	Fraction and variety change composition	Whole-meal or decorticated (7)
Product baked?	Heat alters phenolics	Raw grain versus biscuit (29)
Assay suited?	Methods rank samples differently	Reducing or radical assay (27)
Minerals total or absorbable?	Phytate limits uptake	Total content versus accessibility (18)
Taste tested?	Sets the usable level	Panel acceptance (1)

Note: Questions were applied qualitatively; no scores were assigned.

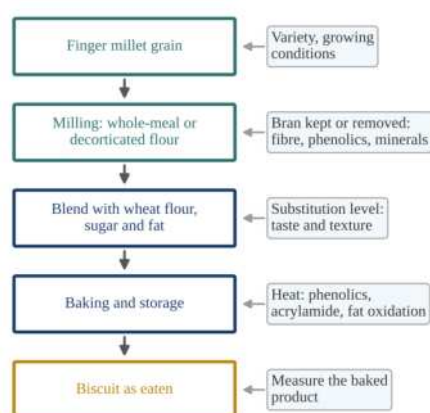


Figure 1. From grain to biscuit and the points where the profile is set (schematic, not data).

4.2 Antioxidant Capacity: What Assays Can and Cannot Say

Most claims of antioxidant value rest on a handful of assays, each of which measures

something slightly different (Table 3). The Folin-Ciocalteu method estimates total reducing capacity and is often reported as total phenolics, though it also responds to other reducing substances (30). Radical-scavenging assays such as ABTS and DPPH, and the ferric reducing assay, give different rankings of the same sample because they work by different chemistry (31, 32, 33).

Reviews of these methods stress that no single assay captures antioxidant behaviour and that a test-tube number says little about the body (27, 28). For a biscuit, the extraction step is a further weak point: a solvent that extracts the free fraction of the flour may miss the bound fraction entirely, and an extract of a baked, high-fat matrix behaves differently from an extract of the raw grain (6). A fair profile uses more than one assay and reports how the sample was prepared (11, 14). The point is not that a study is poor, only that its result travels less far than its abstract suggests.

4.3 Survival Through Processing

The step from flour to biscuit is where the profile can change most (Figure 2). Milling a whole grain keeps its phenolics, whereas decortication takes a large share away with the bran (7), and soaking or fermenting before milling may lower phytate (20, 22) but is rarely used in commercial production. Baking itself has mixed effects. Heat can break down some phenolics and release others from bound forms, so measured antioxidant capacity may fall, stay level or rise (29, 34). Baking also drives Maillard browning and the formation of acrylamide (35, 36), and the water activity of the biscuit sets how fast quality is lost in storage (37). Oxidation of the fat can erode flavour and any antioxidant benefit (38). A benefit that vanishes after baking is not one a consumer will ever taste or absorb.

**Table 3.** Common antioxidant assays and their main caveats.

Assay	What it reflects	Caveat
Folin-Ciocalteu	Total reducing capacity (30)	Responds to non-phenolic reductants
ABTS	Radical scavenging (31)	Depends on solvent and time
DPPH	Radical scavenging (32)	Organic solvent; colour interference
FRAP	Ferric reducing power (33)	Not a radical assay; acidic pH
Combined use	Broader picture (28)	Still not a measure of benefit in people

Note: Caveats are those discussed in the cited methodological reviews.

	Fibre	Phenolics	Mineral access	Fat quality
Whole-meal milling	gain	gain	neutral	neutral
Decortication	loss	loss	mixed	neutral
Soaking or fermenting	neutral	mixed	gain	neutral
Baking	neutral	mixed	neutral	mixed
Storage	neutral	loss	neutral	loss

Schematic of tendencies in the literature, not data

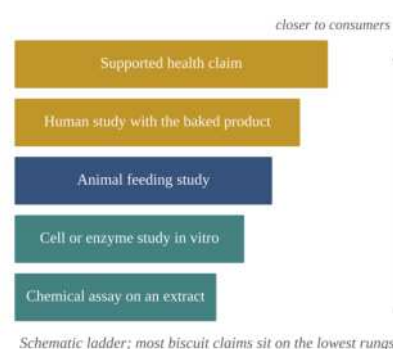
Figure 2. Qualitative effect of processing steps on four attributes (schematic matrix, not data).

4.4 Glycaemic and Health Claims

Finger millet is often marketed for people with diabetes, but the evidence is mixed. Phenolic extracts inhibit starch-digesting enzymes in vitro, and animal work is encouraging (12, 15), but glycaemic response is measured in people, with standard methods (39), and the published tables of glycaemic index values are dominated by other foods (40, 41).

Fibre and whole grain intake have broader support for health benefit (42, 43), and that is probably the most defensible health case for adding more of the whole grain to a

biscuit. It should be stated as a general property of whole-grain foods rather than as a proven effect of finger millet biscuits, and most claims sit on the lower rungs of the evidence ladder (Figure 3). These points hold for any cereal-based snack, not only for this one.

**Figure 3.** Evidence ladder from a laboratory assay to a health claim (schematic, not data).

5. Discussion

5.1 Interpretation

The main finding is conditional. A finger millet composite biscuit is likely to be richer in fibre, calcium and phenolics than a refined-wheat biscuit, but how much richer, and how much of it is nutritionally useful, depends on choices that are often poorly reported: the share of millet flour, whether the bran is kept, whether the grain was pretreated, and how the biscuit was baked (4, 7).

The second conditional concerns antioxidants. The phenolics of the grain are well characterised and clearly active in vitro (10, 11), but the step from a laboratory assay to a nutritional claim is a long one. A claim of antioxidant benefit on a biscuit label would need support from measurements on the baked product, made with a stated method, and ideally from evidence on absorption and effect in people (27). That is a modest claim, and it is the one the literature will currently carry. Nothing in this reading argues against finger millet biscuits; it argues for



measuring what is in them.

5.2 Limitations

This is a narrative review and shares the limitations of that form. The choice of sources reflects judgement, no formal search or quality scoring was used, and some relevant work will have been missed. No numerical results from individual studies are quoted, because they differ with variety, method and laboratory. Read this way, a null result from a small formulation trial is not evidence of absence.

5.3 Directions for Future Work

Three needs stand out. First, studies that analyse flour and finished biscuit side by side with the same extraction and assays, reporting bound as well as free phenolics. Second, measures of mineral accessibility in the baked product. Third, sensory work to find the highest millet share that consumers accept. None of these steps is hard, but each one is easy to skip.

6. Conclusion

Finger millet is a sound candidate for partial replacement of refined wheat flour in biscuits, chiefly for its fibre, calcium and phenolic content. What the published record supports is a plausible improvement in profile, not a quantified one, and the antioxidant and glycaemic claims in particular are better described as promising than proven. Readers should look for formulation details, processing steps and assay methods before accepting any figure, and product developers should describe the flour, keep the bran if phenolics are the aim, and measure the baked biscuit rather than the raw grain.

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9. Conflict of Interest

The authors declare no conflict of interest.

10. Author Contributions

A.T. conceived the review and wrote the sections on cereal composition and formulation. A.V. wrote the sections on antioxidant methods and mineral availability. L.V. wrote the sections on food processing and stability. All authors revised the manuscript and approved the final version.

11. Ethics Statement

This is a review of published literature. No human participants or animals were involved and no ethical approval was required.

12. Data Availability

No new data were generated. All sources are cited in the reference list.

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