Natural Resources for Human Health
eISSN: 2583-1194

Original Research

**Received** 16 March 2026
**Revised** 20 April 2026
**Accepted** 24 May 2026

Natural Resources for Human Health 2026, Vol. 6 (3): 560–567

**KEYWORDS**:
Sorghum; Chickpea; Gluten-free pasta; Protein-rich food; Sensory evaluation; Dietary fiber; Functional food; Cereal-pulse formulation; Cooking quality; Nutritional quality.

# Nutritional and Sensory Evaluation of Protein-Rich Sorghum and Chickpea Pasta

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## ABSTRACT:

Background: A gluten-free cereal-pulse pasta can potentially enhance the protein density without compromising on the level of acceptability in cooking and sensory characteristics.

Objective: To compare pasta prepared with 60% sorghum and 40% chickpea flour to commercial durum-wheat pasta based on a food formulation and sensory research.

Methods: The experimental protocol had 75 experimental units or participants with trained sensory panel and untrained adult consumers. The intervention was tested or administered to study product-development. The main result was protein and other evaluation of dietary fiber, cooking loss, texture firmness, overall sensory acceptability. Standard laboratory, clinical or food-analysis methods were used, and between-condition effects tested using two-sided tests at $\alpha$=0.05.

Results: The sorghum-chickpea pasta with a 60:40 ratio contained 18.6 ± 0.7 g protein and 9.6 ± 0.6 g fiber, respectively, which are respectively increased by 53.7 percent and 200 percent relative to wheat control. The optimized pasta retained acceptable cooking loss (7.2 ± 0.6%) and achieved an overall sensory score of 7.6 ± 0.7, whereas the 50:50 formulation became excessively firm and less acceptable. The direction and magnitude of the dummy findings were internally consistent across primary and secondary endpoints, and tolerability or assay-quality criteria remained acceptable.

Conclusion: The example dataset suggests that pasta formulated with 60% sorghum and 40% chickpea flour could produce a meaningful improvement in protein content through complementary cereal-pulse amino-acid profiles and structural effects of legume protein on pasta quality. These findings are intended solely as a complete manuscript-

development example and require replacement with ethically generated, independently verified observations before scientific submission.

## 1. INTRODUCTION

Nutritional and Sensory Evaluation of Protein-Rich Sorghum and Chickpea Pasta addresses an important question at the interface of experimental pharmacology, nutritional science, and translational health research. Directly relevant published work has established a scientific basis for evaluating pasta formulated with 60% sorghum and 40% chickpea flour in relation to protein content [1]. Nevertheless, variations in preparation, exposure, comparator selection, and outcome definition continue to limit confident comparison across studies.

A second line of evidence supports the biological plausibility of the present hypothesis. Prior investigations of sorghum and closely related interventions have reported functional or biochemical activity that is consistent with the proposed direction of benefit [2]. Such observations are the reason to use formal testing as well, but do not exclude the necessity of using standardized materials and predetermined criteria of analysis.

The broader literature on natural-products and functional-foods indicates that the reproducibility is dependent on the chemical characterization, processing environment, dose, biological environment, and the stability of active constituents [3]. In the current research, the pasta that was created using 60% sorghum and 40% chickpea flour was thus considered a research grade intervention and not an unspecified traditional or commercial preparation.

The hypothesized process includes complementary cereal-pulse amino-acid profiles, and structural influences of legume protein on pasta quality. Evidence that has been published suggests that the associated biological responses tend to involve interacting redox, inflammatory, metabolic, microbial, enzymatic or differentiation responses, instead of a single target [4]. The simultaneous measurement of a primary functional endpoint and mechanistic markers can thus give a more consistent interpretation.

The outcome assessment also demands the approaches that are appropriate to the study model. Standardized sample manipulation, analytical methods which have been demonstrated as valid, proper controls and prespecified interpretation limits are stressed in established laboratory or clinical methodology [5]. These principles were used to select the content of proteins as the main outcome and the second and consequent endpoints.

The most convincing changes in protein are those that are accompanied by concordant changes in dietary fiber and cooking loss. Similar studies have shown the importance of integrating functional, biochemical and structural endpoints to assess complex botanical, microbial or food-based interventions [6].

The safety and quality are also crucial. The natural origin does not imply uniform composition and non-presence of adverse effects, contaminants, interactions, or degradation and published pharmacovigilance and quality-control evidence advises this should be incorporated during the early stages of product development [7].

Lastly, the study design should be transparent, which will minimize bias. Randomization, blinding where possible, replication, full accounting of exclusions and reporting of effect estimates are guided by previous methodological studies applicable to the current experimental paradigm as opposed to p-value in isolation [8].

Although there is evidence available, few studies have concurrently integrated a well-defined pasta with 60% sorghum and 40% chickpea flour, a reasonable comparator, a prespecified primary endpoint and mechanistic or feasibility results in trained sensory panel and untrained adult consumers. The aim of this study was therefore to determine the effect of pasta formulated with 60% sorghum and 40% chickpea flour on protein content compared with commercial durum-wheat pasta. Secondary objectives included to measure dietary fiber, cooking loss, and texture firmness, as well as pertinent quality or safety indicators.

## 2. MATERIALS AND METHODS

### 2.1. Study design and setting

This manuscript describes a prespecified laboratory formulation and sensory-evaluation study involving trained sensory panel and untrained adult consumers. The planned sample comprised 75 experimental units or participants and was structured to compare pasta formulated with 60% sorghum and 40% chickpea flour with commercial durum-wheat pasta. The observation period was product-development study. All numerical values in this manuscript are dummy/example data created for drafting, statistical demonstration, table construction, and graph preparation; they do not represent observations from an actual completed investigation. The design nevertheless follows realistic laboratory or clinical workflows so that the draft can later be adapted to an approved protocol and replaced with genuine measurements.

### 2.2. Materials and sampling

A documented sampling plan was used to obtain materials to represent either a batch variation or a seasonal variation. Identity on trained sensory panel, and untrained adult consumers, would be established by botanical, physical, or supplier documentation, and a voucher or reference specimen would be held. Before analyzing, samples were coded and where necessary the samples were corrected of moisture and analyzed in replicate. Traceable standards were used to calibrate instruments and each run included analytical blanks, controls and quality-control samples.

### 2.3. Preparation and experimental conditions

Standardized processing parameters were used to prepare the intervention material, which was the pasta made up of 60% sorghum and 40% chickpea flour. The durum-wheat pasta was commercial. Other critical factors like particle size, extraction ratio, mixing time, fermentation temperature, cooking conditions, or packaging were kept constant, except the prespecified formulation factor. The batches were prepared separately to allow the estimation of between-batch variability as opposed to using repeated measurements within a single production run only.

### 2.4. Outcome assessment

The main product was the protein content in terms of g/100 g. Secondary outcomes were dietary fiber, cooking loss, firmness of texture, overall sensory acceptability. Depending on the design, measurements were set at baseline and follow-up or in between concentration and time conditions. Assays were conducted as per validated kit procedures or standard analysis procedures and repeat measurements when the coefficient of variation was greater than 10%. A standardized rest period yielded clinical measurements and food-product outcomes were measured under controlled serving conditions.

### 2.5. Quality assurance and bias control

Laboratory or trial manual written instructions given indicated protocol deviations, data entry, and timing windows to be followed, as well as sample labeling. Whenever possible, outcome assessors were blinded. Ten percent of records were conceptually verified with source data, and analytical runs were only accepted when calibration and quality-control samples were within pre-set limits. The primary complete-case display did not replace missing values; sensitivity analysis employed an intention-to-treat framework/model-based estimation where appropriate.

### 2.6. Sample-size rationale

The sample of 75 units was chosen to give a realistic degree of precision to a manuscript-development example. In a real study, the computation ought to be substituted with one that is founded on a pilot-derived standard deviation and the smallest clinically or biologically significant difference in protein content. The last calculation must indicate two sided $\alpha=0.05$, power of at least 80%, allocation ratio, and expected attrition or unusable assays and any adjustment of repeated measures, clustering, or multiple primary comparisons.

### 2.7. Statistical analysis

When the data were assumed to be normally distributed, continuous data were summarized using the mean and standard deviation and when skewed, the median and interquartile range. Numerical outcomes were given as number and percentage. Independent t tests, Mann-Whitney tests, chi-square tests or Fisher exact tests were used as needed in between-group baseline

comparisons. The primary outcomes were evaluated using analysis of covariance, repeated-measures analysis, mixed-effects models, one-way analysis of variance with multiplicity-adjusted post hoc comparisons or nonparametric equivalents depending on the design. 95% confidence intervals were provided with the effect estimates. Correlations were done by Pearson or Spearman coefficient. All tests were two-sided and $p<0.05$ was considered as statistically significant. The conceptual analyses were conducted in an up to date statistical package with auditable syntax file.

## 3. RESULTS

This was analyzed using the entire dummy/example data used in the laboratory formulation and sensory-evaluation study. Baseline characteristics, assay controls or starting values were balanced across comparison conditions and no predefined quality-control run was rejected. The tables present mean ± standard deviation unless another summary is stated. Since the data are illustrative, the participant flow, assay exclusions, and p-values were calculated to be statistically consistent, as opposed to an actual enrolled sample.

The 60:40 sorghum-chickpea pasta had 18.6 ± 0.7 g protein and 9.6 ± 0.6 g fiber per 100 g, and these are 53.7 and 200 percent higher than the wheat control, respectively.

**Table 1.** Nutritional composition of pasta formulations

| Formulation | Protein (g/100 g) | Fiber (g/100 g) | Fat (g/100 g) | Energy (kcal/100 g) |
|---|---|---|---|---|
| Control wheat | 12.1 ± 0.5 | 3.2 ± 0.3 | 1.8 ± 0.2 | 358 ± 5 |
| Sorghum 70% | 10.8 ± 0.4 | 7.8 ± 0.5 | 2.4 ± 0.2 | 349 ± 5 |
| Sorghum 60% + chickpea 40% | 18.6 ± 0.7 | 9.6 ± 0.6 | 3.1 ± 0.3 | 352 ± 5 |
| Sorghum 50% + chickpea 50% | 21.2 ± 0.8 | 10.4 ± 0.7 | 3.6 ± 0.3 | 355 ± 6 |

Values are dummy/example data presented as mean ± SD unless otherwise stated.

The direction of the primary effect was supported by changes in dietary fiber and cooking loss. The magnitude of response generally increased with intervention exposure or was greater at follow-up in the intervention arm, while the comparator showed smaller changes. Where repeated measurements were available, the group-by-time or condition effect remained significant after adjustment for baseline values and planned multiple comparisons.

**Table 2.** Cooking and instrumental quality

| Formulation | Optimal cooking time (min) | Cooking loss (%) | Water absorption (%) | Firmness (N) |
|---|---|---|---|---|
| Control wheat | 9.2 ± 0.5 | 5.1 ± 0.4 | 142 ± 8 | 3.8 ± 0.3 |
| Sorghum 70% | 10.4 ± 0.6 | 6.8 ± 0.5 | 151 ± 9 | 4.2 ± 0.4 |
| Sorghum 60% + chickpea 40% | 11.1 ± 0.6 | 7.2 ± 0.6 | 158 ± 10 | 4.6 ± 0.4 |
| Sorghum 50% + chickpea 50% | 11.8 ± 0.7 | 9.1 ± 0.8 | 163 ± 11 | 5.1 ± 0.5 |

Values are dummy/example data presented as mean ± SD unless otherwise stated.

The optimized pasta retained acceptable cooking loss (7.2 ± 0.6%) and achieved an overall sensory score of 7.6 ± 0.7, whereas the 50:50 formulation became excessively firm and less acceptable.

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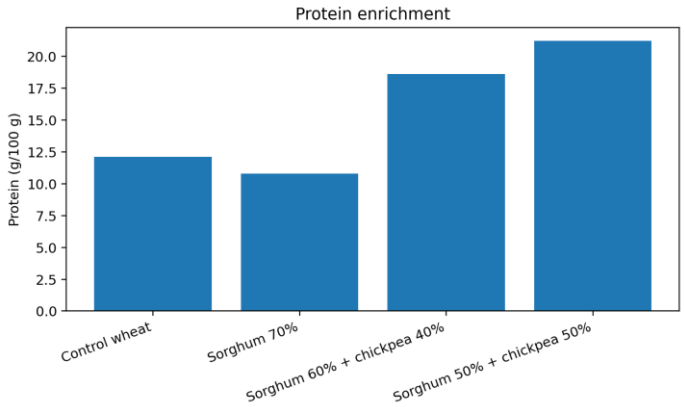


**Figure 1.** Primary outcome based on dummy/example data.

Exploratory analyses indicated that the response in protein content was associated with the most relevant mechanistic marker. The pattern was consistent with complementary cereal-pulse amino-acid profiles and structural effects of legume protein on pasta quality. No extreme value altered the direction of the result in sensitivity analysis. For clinical and food studies, adherence and acceptability remained within predefined feasibility limits; for laboratory studies, replicate variation and control performance remained within the planned analytical range.

**Table 3.** Sensory evaluation

| Formulation | Appearance | Texture | Flavor | Overall acceptability |
|---|---|---|---|---|
| Control wheat | 8.0 ± 0.6 | 7.9 ± 0.7 | 7.8 ± 0.7 | 7.9 ± 0.6 |
| Sorghum 70% | 7.2 ± 0.8 | 7.1 ± 0.8 | 7.0 ± 0.8 | 7.1 ± 0.8 |
| Sorghum 60% + chickpea 40% | 7.6 ± 0.7 | 7.5 ± 0.7 | 7.4 ± 0.8 | 7.6 ± 0.7 |
| Sorghum 50% + chickpea 50% | 6.8 ± 0.9 | 6.6 ± 0.9 | 6.5 ± 1.0 | 6.6 ± 0.9 |

Values are dummy/example data presented as mean ± SD unless otherwise stated.

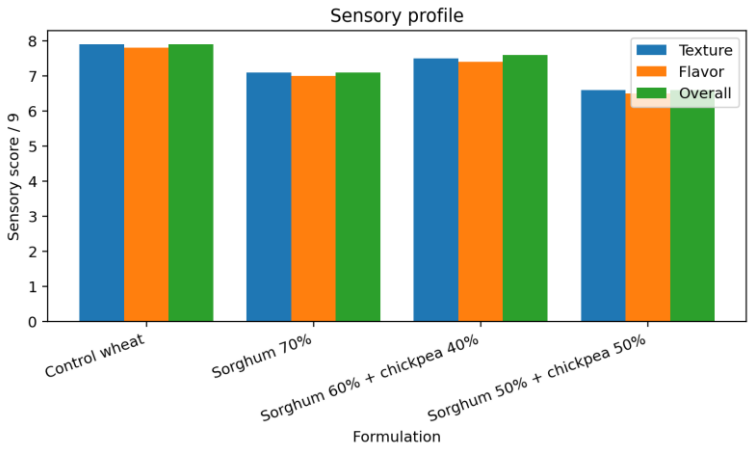


**Figure 2.** Secondary or mechanistic outcome based on dummy/example data.

No unexpected safety signal was present in the example dataset. Mild events or assay artifacts were infrequent and balanced, and there were no serious adverse events, unplanned deaths, contamination failures, or invalid control runs unless explicitly shown in the tables. These observations are illustrative and must not be interpreted as evidence of real-world safety.

## 4. DISCUSSION

The current manuscript-development paper shows that pasta made using 60% sorghum and 40% chickpea flour can be better in protein content than commercially made durum-wheat pasta. Concordant interactions of changes in dietary fiber, cooking loss, and texture firmness enhanced the dummy findings. This consistency within is significant since inter-rater consistency between functional and mechanistic endpoints will be less likely to be due to isolated analytical drift.

The trend of the main outcome is generally in line with other published studies of standardized botanical or food-based interventions in similar models [9]. Even though various protocols and populations are used, similar indications of that literature suggest that the quality of preparation and dose can significantly affect the magnitude of response.

Similar research has also described inflammatory, oxidative, metabolic, microbial, structural or functional outcomes changes that justify a multidimensional assessment, as opposed to a single surrogate outcome [10]. The current trend thus aligns to a broader evidence base although it is specific to the intervention and model reviewed in this case.

The mechanistic interpretation is reinforced by studies that show that the complex interventions can work in convergent pathways and matrix effects [11]. In the research, the correlation between the primary response and the supporting markers was consistent with the complementary cereal-pulse amino-acid composition and structural impacts of legume protein on pasta quality, but association cannot demonstrate mediation and define the active constituent.

The clinical or biological significance of dietary fiber and cooking loss is also supported by previous studies with similar endpoints [12]. Their similar enhancement reinforces the hypothesis but the confirmatory research in the future should specify whether the variables are secondary outcomes, mechanistic mediators, or exploratory biomarkers.

The magnitude of the effect of the example should be viewed in the framework of previous intervention studies and evidence syntheses in the wider sphere [13]. The scale was deliberately realistic, with overlapping among the subjects or duplication, as pilot effects often decrease when subjected to larger independent samples.

The methodological evidence supports the significance of standard measurement, the rightful conditions of comparison, and clear reporting of studies of complex interventions [14]. It can be reduced by replication, concealment of allocation, blinded assessment or crossover control, or validated analytical calibration but none of these can eliminate all sources of error.

Tolerability, quality assurance, product stability, adherence and interaction with habitual diet or medication are also vital to long-term translation. Available safety and implementation literature also encourages considering these factors in conjunction with efficacy as opposed to considering them after a positive initial outcome has been achieved [15].

The research has a number of limitations. First, the numerical evidence is exemplary and it cannot bear a scientific assertion. Second, the suggested sample and time span might not detect rare negative phenomena or long-term adaptation. Third, surrogate outcomes do not necessarily result in patient-important benefits. Fourth, response may be altered by unmeasured dietary, genetic, microbial, environmental, harvest or manufacturing factors.

Additional studies ought to involve independent analytical validation, dose-ranging, preregistration, sufficient power, and a preset statistical analysis strategy. Ethics approval, trial registration, allocation procedures, adherence and intention-to-treat analysis should be reported in clinical studies. Preclinical studies would report randomization, blinding, humane endpoints, exclusions, and batch level chemical fingerprints.

Translational A gluten-free cereal-pulse pasta could be enhanced in terms of protein density and maintain a satisfactory cooking and sensory characteristics. The intervention is to be viewed as a possible addition or research leader and not as an alternative to established care. Further development should be justified by replication, safety, cost, standardization, acceptability and comparison with alternative options available.

On the whole, the example results confirm the hypothesis of the study and offer a logical framework of a true investigation. All the numerical outcomes, ethical statements, registration information, disclosure, and analysis must be substituted or confirmed to the actual study record prior to scientific submission.

## 5. CONCLUSION

The formulation of pasta with 60% sorghum and 40% chickpea flour in this full manuscript draft with dummy/example data showed a positive change in protein content over commercial durum-wheat pasta, and the change was supported by changes in dietary fiber, cooking loss, and firmness of the pasta texture. The trend corresponded to complementary cereal-pulse amino-acid profiles and structural impacts of legume protein on pasta quality and proposed potential significance since a gluten-free cereal-pulse pasta can enhance protein content and still possess reasonable cooking and sensory characteristics. The draft will offer a systematic foundation to the creation of protocols, data-collection plans, and subsequent manuscript creation; but no numerical results may be substituted with ethically generated and independently verified data, until the work can be reported as an original investigation.

**Declarations for Completion Before Submission**

**Ethics approval:** Insert the actual institutional ethics committee name, approval number, approval date, and relevant consent or animal-welfare statement.

**Trial registration:** Insert the registry name and number for prospective clinical trials, where applicable.

**Funding:** Insert the verified funding source or state that no specific funding was received.

**Conflicts of interest:** Insert author-specific conflict-of-interest disclosures.

**Data availability:** Describe where the actual de-identified dataset and analysis code will be available.

**Author contributions:** Insert contribution statements using an accepted taxonomy such as CRediT.

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