# Cereal-based Foods Using Groundnut and Other Legumes

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**Abstract.** *A review of studies conducted on application of flours or concentrates from groundnut, cowpea, and soybean to improve nutritional characteristics of wheat-based bread and cookies, sorghum-based* uji, *and sorghum-based* kisra *are presented. Acceptable cookies were made from composites containing 50% wheat, 35% groundnut, and 15% cowpea flours. At this level of fortification, the protein content was 151% higher than the wheat protein content. Acceptable breads using 70% wheat, 20% groundnut, and 10% cowpea flour had 70% more protein than breads prepared from wheat alone. The composite flours had significantly higher amounts of protein, fat, fiber, and almost all minerals, and lower amounts of tannins than wheat flour. Cowpea flour and soybean concentrate were used to improve the protein content of sorghum-based* uji, *a common food in Tanzania.*

*There was an increase of 40% protein content in the sorghum-cowpea combination (80% sorghum and 20% cowpea), and a 74% increase in sorghum-soybean concentrate combination (80% sorghum and 20% soybean concentrate).* Kisra *is a sorghum-based product, commonly used in the Sudan. Acceptable and nutritionally superior quality* kisra *was prepared from sorghum flour fortified with defatted groundnut flour. The addition of defatted groundnut flour resulted in improvement of baking ease, color, and texture of the final product. The percentage increase in protein content at the 30% level of fortification varied from 53% to 122%. There were significant increases in all essential amino acids. Fortification with groundnut and subsequent fermentation improved the in vitro digestibility of the sorghum flour.*

## Introduction

Grain legumes flours have been used since ancient times. They have been utilized in indigenous foods to (a) extend available wheat grain supplies (supplementation); (b) enhance the nutrient values of food products; or (c) to counteract the effects of inherent

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nutritional inhibitors present in the cereal or legume. Rapid urbanization in developing countries and wheat grain surpluses in developed nations have significantly affected the optimum utilization of grain legumes in indigenous foods. However, in recent years efforts have been made to develop new processing methods to increase utilization of grain legumes in indigenous foods, especially to reduce the amount of wheat imports, and at the same time to increase the nutritional values of cereal-based diets.

This paper is a review of research completed at A & M University in Alabama, on the utilization of grain-legume flours or protein in cereal-based products. The paper includes data on three different food systems: (1) wheat-based bread/cookies using groundnut, or groundnut and cowpea; (2) sorghum-based *uji* using soybean and cowpea; and (3) sorghum-based *kisra* using groundnut.

## Effect of Groundnut Flour on Baking Characteristics of Wheat Flour

The importation of wheat places a severe strain on the limited financial resources of several developing countries in Africa. In these countries, groundnut cake (after oil extraction) is available in abundance, notably in the Sudan and other Sahelian countries. It is possible that the cake could be converted to flour to supplement or fortify other flours. The advantages of developing such a technology are two-fold. It could enhance the protein level in the diet, and reduce food imports. Since cowpea is a commonly available legume, composites were made using wheat and cowpea flours.

Twelve different composites were prepared using wheat flour (cv Coker-747), partially (PD), and fully (DF) defatted groundnut flour (cv Florunner), and cowpea flour (Table 1).

**Table 1. Proportion of wheat, groundnut, and cowpea flour in composite flours.**

| Treatment | Wheat (%) | Groundnut[1] PD (%) | Groundnut[2] DF (%) | Cowpea (%) |
|---|---|---|---|---|
| 1 | 100 | 0 | 0 | 0 |
| 2 | 0 | 100 | 0 | 0 |
| 3 | 0 | 0 | 100 | 0 |
| 4 | 0 | 0 | 0 | 100 |
| 5 | 85 | 10 | 0 | 5 |
| 6 | 85 | 0 | 10 | 5 |
| 7 | 80 | 10 | 0 | 10 |
| 8 | 80 | 0 | 10 | 10 |
| 9 | 70 | 20 | 0 | 10 |
| 10 | 70 | 0 | 20 | 10 |
| 11 | 60 | 30 | 0 | 10 |
| 12 | 60 | 0 | 30 | 10 |
| 13 | 50 | 25 | 0 | 15 |
| 14 | 50 | 0 | 25 | 15 |
| 15 | 50 | 35 | 0 | 15 |
| 16 | 50 | 0 | 35 | 15 |

1. PD = partially defatted groundnut with 30% fat level.
2. DF = defatted groundnut with 18% fat level.

Farinographic studies and proximate analyses were carried out using standard methods (AACC 1962). Minerals and phytic acid contents were determined (Singh and Reddy 1977). Tannin concentration was determined by the vanillin-hydrochloric acid method (Burns 1971). Trypsin inhibitor activity (TIA) and aflatoxins were determined according to the AOAC methods (AOAC 1975). Taste panel studies were conducted on the bread and cookies, with the composites being compared with wheat flour preparations, which were used as controls.

Bread-baking parameters, such as absorption, optimum mixing time, and loaf volume decreased with increased amounts of groundnut and cowpea flours in the formulations (Table 2). Specific volumes of the bread decreased when groundnut and cowpea flours replaced wheat in the blends. The trend indicated that the higher the groundnut content in the blend, the lower was the volume. The most acceptable bread-making blend, in terms of loaf volume, was 85% wheat, 10% PD or DF groundnut, and 5% cowpea (Table 2). Taste-panel evaluations were conducted. Panelists graded the bread out of a possible score of 100. The blends used in this evaluation were those containing levels up to 30% of groundnut and 10% of cowpea flours, as substitutes for wheat flour. Higher substitution levels of groundnut and cowpea flours produced doughs that could not be baked into satisfactory breads. At the 10% of cowpea flour substitution level, a beany flavor was detected.

The blends were more suitable for baking cookies than bread. There was little difference between the diameters of the cookies made from wheat and the PD groundnut blends. As DF groundnut flour was increased in the blends, the diameters of the cookies decreased. PD groundnut blends produced cookies with a higher diameter than the corresponding DF blends. Results however showed that the DF groundnut blends had

**Table 2. Characteristics of most acceptable blends of wheat, groundnut, and cowpea flours for bread and cookie manufacture[1].**

| Flours (%) | | | | Loaf volume (cc) | Specific loaf volume (cc $g^{-1}$) | Cookie volume (cc) | Bread score | Cookie score | Protein (%) |
|---|---|---|---|---|---|---|---|---|---|
| W: | PD: | DF: | B(2) | | | | | | |
| 100 | - | - | - | 448a[3] | 3.10a | 69.6a | 76.2d[4] | 8.3a[5] | 9.7f |
| 85 | 10 | - | 5 | 371b | 2.49b | 62.5c | 78.3a | 8.0b | 12.3e |
| 85 | - | 10 | 5 | 339c | 2.37bc | 68.2a | 75.1e | 7.7c | 13.7d |
| 80 | 10 | - | 10 | 320d | 2.25c | 61.6c | 77.9b | 7.5c | 14.1d |
| 70 | 20 | - | 10 | 310e | 2.17d | 58.5d | 77.0c | 7.1d | 16.6c |
| 50 | 35 | - | 15 | - | - | 64.1b | - | 8.1b | 20.8b |
| 50 | - | 35 | 15 | - | - | 64.7b | - | 8.1b | 24.4a |

1. Mean of three replications.
2. W = wheat; PD = partially defatted groundnut; DF = defatted groundnut; B = cowpea.
3. Means noted with different letters following are significantly different ($P < 0.05$) based on Duncan's Multiple Range Test.
4. A subjective score was given based on nine panel members : Breaks and shred-6; crust color-7; symmetry-7; crumb color-10; volume-15; flavor-15; grain-20; and texture-20. Total 100.
5. Ratings for cookie evaluation were based on nine panel members : 0-4 poor; 5-below average; 6-average; 7-above average; 8-good; 9-very good; and 10-excellent.



17

significantly higher values for volume than the PD blends. Wheat flour cookies were rated the best followed by cookies made of flours with 35% groundnut and 15% cowpea. Characteristics of most blends for baking cookies and baking bread are presented in Table 2.

Proximate compositions of individual flours and of the blends used to prepare the most acceptable bread and cookies showed that the protein levels in them ranged from 12.28% to 24.40%. As the amount of groundnut flour increased in the composites, the fiber and ash levels also increased.

Among the flours under study, DF groundnut flour had higher concentrations of all the minerals except potassium and sodium. Cowpea flour had the highest potassium content. As the quantity of groundnut and cowpea flours were increased in the composites, the levels of all minerals except sodium increased over those obtained in wheat products. None of the flours had detectable levels of aflatoxin. Phytic acid levels were highest in the DF groundnut flour, followed by PD groundnut, cowpea, and wheat flour. The composites with DF groundnut and cowpea flour had significantly higher phytic acid levels than corresponding composites with PD groundnut and cowpea flour. Wheat had the highest tannin content followed by cowpea, DF, and PD groundnut flours. There were no significant differences between the tannin levels of the composite flours. However, tannin levels were significantly lower in composite flours than in wheat and cowpea flours. The trypsin inhibitor activity (TIA) in PD and DF groundnut flours was lower than in wheat and cowpea flours. Levels of TIA in the composites were lower than in the individual flours.

## Conclusion

Groundnut flour after partial or full removal of fat can be utilized to increase the protein content of cereal-based food products. It can be bleached to improve acceptability. The addition of groundnut flour resulted in an increase of protein, a reduction of tannins, and the enhancement of some desirable minerals. A possible extension of this study will be the fortification of sorghum-based foods with groundnut flour in the Sudan and other Sahelian countries.

## Effects of Soybean Protein Concentrates and Cowpea Flours on Acceptability and Nutrient Compositions of Sorghum-based *Uji*

*Uji* is a food product commonly prepared from maize or sorghum in Tanzania. The most limiting amino acids in sorghum protein are lysine, threonine, and methionine (Paul and Fields 1981). In addition to its poor quality and low protein content, sorghum contains tannins, which decrease the availability of proteins (Chavan et al. 1979). In areas where sorghum is a staple diet, there is a need to have a nutritional improvement program on sorghum. In this study, soybean concentrate and cowpea flour were used to improve the protein quality of sorghum flour.

Nine different composite flours were prepared using sorghum flour, soybean concentrate, and cowpea flour (Table 3). Soybean concentrate and cowpea constituted up to 20%

**Table 3. Time taken to cook *uji* with different flour blends.**

| Treatment | Sorghum (%) | Maize (%) | Soybean[1] (%) | Cowpea (%) | Time (min) |
|---|---|---|---|---|---|
| 1 | 100 | 0 | 0 | 0 | 45 |
| 2 | 75 | 25 | 0 | 0 | 45 |
| 3 | 50 | 50 | 0 | 0 | 45 |
| 4 | 80 | 0 | 20 | 0 | 75 |
| 5 | 85 | 0 | 15 | 0 | 65 |
| 6 | 90 | 0 | 10 | 0 | 60 |
| 7 | 80 | 0 | 0 | 20 | 60 |
| 8 | 85 | 0 | 0 | 15 | 55 |
| 9 | 90 | 0 | 0 | 10 | 50 |

1. Soybean protein concentrate.

of the total composite flour; maize did not constitute more than 50% of the composition. Proximate composition, minerals, phytic acid, and tannins were determined as described earlier. Amino acid determinations were made using standard procedures. Gelatinization characteristics were determined by using a Brabender amylograph (AACC 1962).

*Uji* was prepared by adding 200 g flour to 1200 mL of warm water while stirring. The mixture of water and flour was allowed to boil for 45-75 min depending on the composition of the flour. The cooking time for each composite flour was established after running several trials. While cooking, two tablespoons of lemon juice and three table spoons of sugar were added to each *uji* formulation. A panel of tasters consisting of nine students from eastern Africa evaluated the products for their flavor, degree of cooking, after-taste, mouth feel, and consistency.

Sorghum-maize blends of *uji* (50:50 and 75:25) were both rated as highly acceptable (Table 4). One of the reasons for the low rating of cowpea was its strong beany flavor.

**Table 4. Taste panel results of *uji* prepared using various blends[1,2].**

| Treatment | Mean scores | Rank |
|---|---|---|
| Sorghum:cowpea (80:20) | 1.88 | 9 |
| Sorghum:soybean[3] (80:20) | 2.44 | 8 |
| Sorghum:cowpea (85:15) | 2.88 | 7 |
| Sorghum (100%) | 3.11 | 6 |
| Sorghum:cowpea (90:10) | 3.33 | 5 |

*Continued.*

**Table 4.** *Continued.*

| Treatment | Mean scores | Rank |
|---|---|---|
| Sorghum:soybean[3] (90:10) | 3.55 | 4 |
| Sorghum:maize[3] (85:15) | 3.77 | 3 |
| Sorghum:maize (75:25) | 4.22 | 2 |
| Sorghum:maize (50:50) | 4.88 | 1 |
| LSD | 0.11 | |

1. Values reported are the average values of duplicate determination.
2. Treatment with the highest mean score is the most acceptable treatment (formulation) and the treatment (formulation) with least mean score is the least acceptable formulation or treatment.
3. Soybean protein concentrate.

The starch gelatinization properties of the composites were studied. The difference in gelatinization temperatures is due to the size of the starch granules. A lower gelatinization temperature in any starch grain would be desirable to reduce cooking time. In this study, maize and cowpea were found to have lower gelatinization temperatures, followed by sorghum and soybean protein concentrate.

The soybean concentrate significantly increased the protein content of sorghum flour and lowered tannin levels. However, phytate and mineral levels increased significantly. Limiting essential amino acids, including lysine, were significantly increased, and the increase in lysine ranged from 21% to 35%. The cowpea flour also increased the levels of essential amino acids and mineral contents, but the levels of tannins and phytate were not reduced. The iron content increased more than 30% in all the composites developed from sorghum and cowpea flours.

## Utilization of Defatted Groundnut Flour in Preparation of Sorghum-based *Kisra*

*Kisra* is a thin pancake-like leavened bread made from whole sorghum flour. It is the predominant staple diet of people in the Sudan. In the Sudan, groundnut cake (after oil extraction) is exported. It is possible to convert the cake into flour for local consumption. The objectives of this study were to determine the effect of the addition of defatted groundnut flour on the *kisra*-making quality and nutrient composition of sorghum flour.

Sorghum flour was prepared from the cultivar Dabar obtained from the Sudan. Defatted groundnut flour was obtained from a flavored-nuts company (Seabrook Blanching Corporation, North Carolina, USA). The starter for fermentation was obtained from the Sudan in



- 6

a powdered (sun-dried) form and was typical of the local product used to make *kisra*. It is derived from wild yeasts that occur naturally in fermented sorghum flour.

Fermented dough and *kisra* were prepared in the traditional way employed by the typical Sudanese housewife. Sorghum flour (90 g) was mixed with water (120 mL) and the starter (30 g) in a stainless steel beaker. After thorough mixing the mash was incubated in a fermentation cabinet at 27°C for 18-20 h. At the end of the fermentation process the pH had reached 3.9-4.0. Just before baking, another 60 mL of water was added. The batter was baked for 1.5-2.0 min on a hot plate at 150-160°C to a thin-sheet consistency. Baking ease was determined by weighing the residues collected on the surface of the hot plate after the removal of the product. Acceptability, color, texture, and keeping quality were determined by a panel of eight members, composed of Sudanese and Ethiopians familiar with *kisra*. Proximate composition and amino acids were determined as described earlier, and in vitro digestibility was determined according to Osilaja (1986).

The effect of various levels of fortification on baking ease, color, taste, and acceptability are presented in Table 5. The addition of defatted groundnut flour appeared to decrease the residue and improve baking ease, and hence increase the yield of the final product. Acceptable *kisra* was obtained with fortification up to the 30% level with defatted groundnut flour. Taste, color, and texture were not significantly influenced, and this may probably be due to the use of colorless groundnut flour. The keeping quality was reduced after 24 h at room temperature. However, *kisra* is generally used within 24 h after baking. Amylograph curves for the composites showed that the defatted groundnut flour decreased the heights of peak viscosity.

There was a significant increase (73%) in the amount of protein added by fortification. The amino acid compositions in the fermented blends and in *kisra* showed that fortification increased the amounts of all amino acids. The increase in the lysine content was 102% when fortification was at the 30% level. Fortification and subsequent fermentation improved in vitro digestibility and reduced the leucine/isoleucine and the leucine/lysine

**Table 5. Baking-ease and sensory evaluation of *kisra* from 'Dabar' flour fortified with defatted groundnut flour.**

| Fortification level (% defatted groundnut flour) | Residues on the hotplate (g) | Color[1] | Texture[1] | Taste[1] | Overall acceptability after[1] 24 h at room temperature |
|---|---|---|---|---|---|
| 0 | 4.10a[2] | 4.22e | 3.62b | 3.58a | 3.20a |
| 10 | 4.08a | 4.26d | 3.68b | 3.52a | 3.18a |
| 15 | 3.88b | 4.28c,d | 3.69b | 3.57a | 3.03b |
| 20 | 3.80b | 4.31b,c | 3.75a,b | 3.53a | 2.78c |
| 25 | 3.68c | 4.33a,b | 3.76a | 3.56a | 2.70c,d |
| 30 | 3.60c | 4.35a | 34.03a | 3.55a | 2.63c |

1. Means of 8 individual observations as rated on a hedonic scale of 1-5, where 5 = excellent and 1 = very poor.
2. Means of any parameter with the same letter are not significantly different ($P = 0.05$) using Duncan's Multiple Range Test.

**Table 6. Ratios of amino acids as quality indices and in vitro digestibility of sorghum flour from cultivar 'Dabar' with indicated levels of defatted groundnut flours.**

| Sample | Leucine/ isoleucine | Leucine/ lysine | E/T[1] | Pepsin-pancreatin digest (%) |
|---|---|---|---|---|
| Sorghum flour | 4.91 | 6.13 | 2.65 | 66.2 |
| Fermented dough | 4.78 | 5.98 | 2.62 | 67.4 |
| *Kisra* | 5.71 | 6.23 | 2.65 | 66.7 |
| 10% blend | | | | |
| Fermented dough | 4.75 | 6.16 | 2.61 | 67.0 |
| *Kisra* | 5.10 | 6.55 | 2.57 | 66.7 |
| 15% blend | | | | |
| Fermented dough | 3.96 | 4.11 | 2.55 | 68.9 |
| *Kisra* | 4.28 | 3.88 | 2.49 | 67.5 |
| 20% blend | | | | |
| Fermented dough | 3.26 | 2.84 | 2.45 | 69.5 |
| *Kisra* | 3.14 | 3.25 | 2.43 | 68.9 |
| 25% blend | | | | |
| Fermented dough | 3.36 | 2.43 | 2.42 | 70.3 |
| *Kisra* | 3.12 | 2.84 | 2.24 | 68.9 |
| 30% blend | | | | |
| Fermented dough | 2.74 | 2.18 | 2.40 | 72.5 |
| *Kisra* | 2.69 | 2.72 | 2.18 | 69.7 |
| FAO/WHO (1973) | | | 2.25 | |

1. The proportion of total amino acids (T) that must be supplied as essential amino acids (E).

ratios for composite flours (Table 6). It has been suggested that a leucine/isoleucine ratio higher than 3.0 should be regarded as deleterious. Apparently, fortification resulted in the reduction of the ratio. The proportion of total amino acids (T) that must be supplied as essential amino acids (E), the E/T ratio is considered as a quality index in the FAO Provisional Pattern (FAO/WHO Adhoc Expert Committee 1973). Sorghum flour by itself seemed to have an acceptable E/T ratio due to its higher leucine and phenylalanine contents. The 30% level of fortification showed a lower E/T ratio. In vitro digestibility was improved by the addition of defatted groundnut flour.

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9