varieties. Generally, higher percentages of oleic or linoleic acid in the triacylglycerol resulted in a greater proportion of the fatty acid in the *sn*-2 position and, consequently, less at the exterior positions. The exception to this trend was found in peanuts grown at Headland, AL. In each variety, the proportion of linoleic acid at the *sn*-2 position was greater than at any other growing location, although the concentration in the triacylglycerols was not the highest of the 4 locations.

The data presented make obvious the fact that environment affects not only fatty acid composition of peanut oil, but also, although apparently indirectly, the spatial arrangement of those acids on the triacylglycerol molecules. Because peanut triacylglycerol structure and composition and total oil composition have been associated with such factors as atherogenic potency (16) and oxidative stability (17), the far-reaching implications of different growing locations are obvious.

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# Preparation and Composition of a Dry-Milled Flour from Cowpeas[1]

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## ABSTRACT

Cowpeas having a smooth, brown, loosely adhering seedcoat (Mississippi Silver Hull Crowder) were milled to a flour by coarsely cracking the dry (12% $H_2O$) peas on a Morehouse Mill, aspirating the seedcoats on a peanut sheller, and reducing the cotyledon fraction to a flour by several passes through the Morehouse Mill. The flour was produced in 88% yield from the starting peas. The proximate composition of resulting flour differed from that of whole peas principally in fiber content (2.5 vs 7.1% ADF), and also contained (dsb) 26% protein, 1.6% fat, 3.3% ash and ~67% NFE. Seed coat removal also reduced tannin content and effective trypsin inhibitor activity of the flour. The essential amino acid profile of cowpea flour resembled that of soy flour, but was somewhat lower in the limiting sulfur amino acids.

## INTRODUCTION

Starchy legumes represent a greatly underused source of protein, calories and B vitamins for world-wide nutrition, and of potential ingredients for the food industry. However, there are relatively few commercial ventures which process non-oilseed legumes into food ingredients.

Cowpeas (*Vigna unguiculata*), more commonly known in the U.S. as Southern, or black-eyed, or crowder peas, depending on the type, are an important source of protein in the developing world, especially West Africa (1). Their potential for increasing protein consumption in the developing countries is such that the Protein Advisory Group (FAO/UN) has recommended this crop be accorded priority research status (2).

In Africa, peas are prepared for consumption in a great variety of ways. Many applications call for removal of the seed coat and grinding the cotyledons to a paste prior to cooking. This is most often accomplished by soaking the peas and manually rubbing to loosen the seed coat. Alternatively, hydratable flours are produced by small-scale, dry, or combined wet and dry milling operations (1).

The laborious, time-consuming nature of traditional seed coat removal and grinding has been emphasized as one of the constraints on increased consumption of peas (1). Accordingly, several researchers have investigated wet and dry milling schemes aimed at circumventing this barrier (3-5). Dry milling has several advantages over wet milling in developing as well as in industrialized countries. Energy requirements are lower due to elimination of the drying step; microbial contamination is more easily avoided; and liquid waste streams are not generated. However, cowpea cotyledons are much softer than cereal endosperm tissue, and higher milling losses of desirable material result when abrasive dry milling is used. Abrasive, rather than attrition, milling of cowpeas has been emphasized because most African varieties have tightly adhering seed coats which are not readily released in the absence of water. In contrast, several cultivars of the "crowder" type, popular in the Southern U.S., have smooth, brittle, loosely adhering seed coats which are easily removed by cracking and aspiration. This paper describes the production and composition of a

[1]Presented at the AOCS meeting, May 1981, in New Orleans.

flour from such a variety: Mississippi Silver Hull crowder peas.

## MATERIALS AND METHODS

Mississippi Silver Hull crowder peas were obtained through a local supplier from the Pennington Seed Company, Madison, GA, and were stored at 10 C. Seeds were not tempered or otherwise treated prior to milling.

### Milling

Milling was carried out on three 1.0-kg batches of peas.

The first step in milling peas was to coarsely break the seeds to free the seed coats. This was done by feeding the peas at a rate of 500 g/min through a Morehouse mill (Morehouse Industries, Los Angeles, CA). This mill features a stationary abrasive surface and a rotor, with both an abrasive surface and shearing blades, which spins at 10,000 rpm. The clearance between the surface is adjustable by raising or lowering the rotor. For cracking the peas, the rotor was lowered to its maximal clearance of 5.3 mm. This minimizes the degree of shattering and results in most seeds being broken into intact cotyledons, embryos and pieces of seed coat. These components were separated into two fractions by passing the cracked seeds through a Federal-State Inspection Service peanut sheller. The oscillating bed of the sheller metered the cracked seeds onto a chute which is positioned underneath an aspirator. The aspirator is composed of a rectangular duct, 64 $cm^2$ in cross sectional area located 2.0 cm above the chute. Air is drawn through the duct at a rate of 1.45 $m^3$/sec by a 4-veined blower fan. As a result of this process, most of the seed coats and a small part of the embryos were aspirated whereas cotyledons, and the remaining embryos traveled down the chute into a receiving vessel. The cotyledon fraction was passed through the sheller several times to maximize seed coat removal. The decorticated cotyledon fraction was reduced to a flour by a series of passes through the Morehouse mill at successively closer spacings of the stones. Final clearance was 0.03 mm.

### Analyses

Particle size distribution of the flours was determined by shaking weighed batches (~300 g) of flour on a stack of standard screens for 3 hrs.

Prior to analysis, samples of whole peas, cotyledon flour and seed coat fraction were finely milled (≤200 mesh) on a Retsch mill (Micro Materials Corporation, Manhasset, NY) equipped with a screen with 80 μm holes. Analyses for nitrogen, moisture, fat and ash were carried out in duplicate by Standard AOAC Methods (6). Acid detergent fiber was analyzed by a modification of the method of Van Soest (7). Tannin content was determined by the method of Burns (8) as modified by Price et al. (9), except that tannins were expressed as catechin equivalents (uncorrected). Trypsin inhibitor activity was determined by the method of Kakade et al. (10). Nitrogen-free extract (NFE) was determined by difference.

Amino acid analysis was performed by ion exchange chromatography on a Durrum D 500 analyzer equipped with a 1.75 mm x 48 cm column packed with Dionex DC-4A resin. Acid hydrolyzates were prepared according to an accelerated method developed in this laboratory (11), and were used for determination of all protein amino acids except cystine and tryptophan. Chromatographic conditions were those recommended by the manufacturer. Cystine-cysteine was determined following performic acid oxidation as described by Moore (12) except that, following hydrolysis, samples were processed as described in reference 11. Chromatography was carried out as for acid hydrolyzates, but only the first buffer was used as cysteic acid emerges at the buffer front. Tryptophan was analyzed following release by alkaline hydrolysis as described by Hugli and Moore (13).

## RESULTS AND DISCUSSION

Mass distributions of seed components following hand-dissection, and mechanical milling as already described, are shown in Table I. The cotyledon fraction appeared to contain most of the germ and a small amount of remaining seed coat. The yield is reasonable in light of the rather high seed coat content of this variety compared to that reported for African varieties (5). Particle size distribution of the cowpea flour is given in Table II. The relative large amounts of ca. 60 mesh and < 140 mesh flours indicate the formation of "break flour" and a coarser particle, much as is observed in the milling of cereal grains. Proximate analyses of the whole peas and mill fractions are shown in Table III. The milling operation resulted in little change in gross composition of the flour, except for the fiber content which was considerably reduced. The seed coat fraction is composed mainly of fibrous constituents, but contains a significant amount of protein as well. Fiber has been reported to have both beneficial and antinutritional properties (14). In Africa, there is considerable opinion against feeding cowpea products to children due to the indigestible nature of the seed coat, and also the belief that even small amounts of residual seed coat interfere with the functional behavior of pastes made from peas (1). Support is given to these beliefs by data in Table IV. The seed coat contains a significant amount of tannin which is known to bind soluble protein (15), interfere with digestion (16), and which probably also accounts for the high apparent trypsin inhibitor activity in the seed coat fraction (17). Trypsin inhibitor content of the cotyledon fraction is somewhat less than that of the whole pea as would be expected, and is much less than that found in soybeans (18) or in *Phaseolus* species (19). It is interesting that the trypsin inhibitor of whole pea is about ½ of what would be expected based on the value for the cotyledon and seed coat frac-

**TABLE I**

**Distribution (%) of Cowpea Seed Components Following Fractionation[a]**

| Hand-dissected peas | | Mechanically milled peas | |
|---|---|---|---|
| Cotyledone | 85.4 | Cotyledon fraction | 88 |
| Seed coats | 12.8 | Seed coat fraction | 12 |
| Embryos | 1.8 | | |

[a]Values are average of 3 determinations.

**TABLE II**

**Particle Size Distribution of Cowpea Flour[a]**

| Retained on screen size | Total flour (%) |
|---|---|
| 20-mesh | 3.1 |
| 30-mesh | 1.0 |
| 60-mesh | 27.0 |
| 80-mesh | 7.7 |
| 140-mesh | 8.5 |
| Pan | 50.0 |
| Total recovered | 97.3 |

[a]Mean of duplicate determinations.

**TABLE III**

**Analyses[a] of Cowpea Fractions**

| | Whole peas | Cotyledon fraction flour | Seed coat fraction |
|---|---|---|---|
| Water | 12.9 | 13.1 | 12.7 |
| Oil[b] | 1.4 | 1.6 | 0.3 |
| Crude protein (N X 6.25)[b] | 24.9 | 25.8 | 10.9 |
| Ash[b] | 3.3 | 3.3 | 2.3 |
| Acid detergent fiber[b] | 7.1 | 2.5 | 45.1 |
| NFE by difference[b] | 63.3 | 66.8 | 41.4 |

[a]Mean of duplicate determinations.
[b]Moisture free basis.

tions. This was consistently observed, and might be due to interaction between the small, soluble trypsin inhibitor protein (20) and tannins which readily react with such species (15). Thus, these two antinutritional factors may partially counteract each other under some conditions. Listed in Table V are the essential amino acid profiles for whole peas and the mill fractions. All fractions are rich in lysine, but are rather severely limiting in sulfur amino acids. Other essential amino acids are present in acceptable amounts compared to the FAO profile (21). There is surprisingly little difference between the cotyledon and the seed coat fractions in essential amino acid profiles. However, some nonessential amino acids (data not shown) exhibited a greater degree of variation. Based on the composition of these fractions, one would expect the flour to find applications in human food, whereas the seed coat fraction might be of interest as a feed for ruminants.

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**TABLE IV**

**Antinutritional Factor Content[a] of Cowpea Fractions[b]**

| | Whole pea | Cotyledon fraction | Seed coat fraction |
|---|---|---|---|
| Tannin (%) | c | c | 5.3 |
| Trypsin inhibitor (TI units/mg) | 12.4 | 11.4 | 123.3 |

[a]Mean of duplicate determinations.
[b]Dry basis.
[c]Not detectable under extraction conditions used.

**TABLE V**

**Essential Amino Acid Profile of Cowpea Fractions (g/16-g Sample Nitrogen)**

| | Fraction | | | |
|---|---|---|---|---|
| Amino acid | Whole[a] peas | Cotyledon[a] fraction | Seed coat[a] fraction | FAO reference pattern |
| Lysine | 7.0 | 7.2 | 6.3 | 5.5 |
| Methionine | 7.1 | 1.2 | 0.9 | 3.5 |
| Half-cystine | 0.9 | 0.9 | 1.0 | |
| Threonine | 3.9 | 3.9 | 3.5 | 4.0 |
| Isoleucine | 4.1 | 4.2 | 3.7 | 4.0 |
| Leucine | 7.8 | 8.0 | 6.5 | 7.0 |
| Valine | 4.9 | 5.0 | 4.6 | 5.0 |
| Tyrosine | 3.2 | 3.3 | 3.6 | 6.0 |
| Phenylalanine | 5.5 | 5.6 | 4.3 | |
| Tryptophan | 1.3 | 1.2 | 1.1 | 1.0 |
| Recovery[b] | 90.1% | 91.6% | 85.6% | |

[a]Mean of duplicate determinations.
[b]Percentage sample nitrogen recovered as amino acid plus ammonia nitrogen.

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