Functional Characteristics of Cowpea Flours in Foods[1]

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Functionality of legume flours as food ingredients is influenced by genetic and agronomic factors, storage, composition and processing. The processing of flour from dry cowpeas *(Vigna unguiculata)* is a simpler technology than that utilized for oilseed flour production. A defatting step is not required because the crude fat content of cowpeas is low (∼1–2%); however, decortication (seed coat removal) is necessary if a light-colored flour is to be obtained from cultivars with dark testa or eyes. Process conditions employed in the decortication of cowpeas and production of cowpea flour influence the quality of subsequent products made from the flour. Functionality of cowpea flour as an ingredient in wheat flour mixtures, akara and moin-moin (fried and steamed cowpea paste, respectively), extruded products and meat products will be reviewed.

The cowpea *(Vigna unguiculata)* is a legume of world economic importance (1). Widely grown in Africa, India and Brazil, cowpeas constitute a primary source of protein and carbohydrate for populations of these countries and contain 23–30% and 56–68% of these nutrients, respectively (2). Although cowpea seeds are typically consumed as a boiled vegetable—alone or in combination dishes (3,4), considerable interest has developed in expanding usage of cowpeas in other forms such as flour, paste and extruded products.

Because of the low fat content (∼1–2%) of the dry seed, production of a flour-like product from cowpea is simpler than that required for products derived from oilseed sources, which involve extraction of some or nearly all of the oil. Removal of the seed coat, i.e., decortication, is necessary if a light-colored flour is to be obtained from cultivars which have a dark testa or eye (hilum). Cultivars which have smooth, brittle, loosely adhering seed coats (e.g., crowder type) may be easily decorticated by cracking and aspiration, whereas cultivars with tightly adhering testa require wetting to facilitate decortication (5).

Functionality has been described as any property of a food or food ingredient except nutritional ones which affect utilization (6). Proteins are usually linked to such functional properties as solubility, water absorption and binding, viscosity, gelation, cohesion-adhesion, elasticity, emulsification, fat absorption, flavor binding, foaming and color control (7), whereas starch is usually associated with swelling and solubility, water absorption, viscosity, gelatinization and gelation (2,8). Although carbohydrate is the major component of legumes, the protein component has received considerably more attention.

Functional properties of proteins are influenced by genetic and agronomic factors, storage, composition and processing (9), and may be altered by physical, chemical or biological means (6). Tests to assess functionality have involved model systems which limit the number of variables being evaluated at a given time and utility tests which evaluate performance in an actual food formulation (6). Although both types of test systems provide useful information, this presentation will focus primarily on the functional characteristics of cowpea flour used as an ingredient in food systems.

COWPEA FLOUR IN WHEAT FLOUR MIXTURES

Recognized as a food which is consumed almost universally, bread has frequently been used as a medium for investigating the functionality of non-wheat flours. Supplementation of hard wheat flour (14% protein) with legume flours in bread formulations is an effective means of increasing the amount and improving the quality of protein; however, legume flour used at levels which substantially reduce the amount of wheat flour gluten adversely affects dough-forming properties and final product quality.

Okaka and Potter (10) found that a blend of 90% wheat flour/10% drum dried cowpea powder produced excellent quality yeast bread. Although loaf volume decreased progressively as cowpea powder level increased above 10%, the effect was minimizezd by including surfactants in the bread formula. A 30% level of cowpea powder produced unacceptable bread even with the addition of a surfactant. A subsequent study by these authors (11) showed that cowpea powders made from peas that had been soaked in pH 2, 4 or 6 water to produce varying degrees of beany flavor and used at a 20% wheat flour replacement level produced highly acceptable breads.

Mustafa *et al.* (12) used cowpea flour made from non-decorticated peas in yeast bread and found that a 10% cowpea flour level produced bread which was very similar in quality to an all-wheat flour control. Increasing levels of cowpea flour increased water absorption and decreased dough development time, stability time and dough softening time. Levels of 15 and 20% cowpea flour produced bread with noticeable black specks, beany flavor and low specific volume. Sales (13) reported that yeast bread made with spray dried cowpea flour had a dark brown color and slightly compact texture. However, cowpea flour produced by a simple dry roast/dry mill process and used at a 35/65 cowpea/all-purpose or whole wheat flour ratio resulted in bread that had a very acceptable loaf volume, texture, color and flavor.

McWatters (14) prepared cowpea flour from cream-type peas that were sufficiently light in overall color (seed coat and hilum) that they could be dry milled without decortication. Cowpea flour was used at a level which completely replaced the milk protein in a chemically-leavened quick bread (biscuits). Substantial changes were noted in some sensory attributes, crust and crumb colors and density. The beany aroma and flavor of the cowpea flour biscuits was somewhat lessened by preliminary steaming of the cowpea flour.

Cookies are a good medium for evaluating functionality of composite flours because their dough structure does not involve the dependency on a well-developed gluten framework that bread systems require. The flour in cookie formulations is usually an all-purpose type made from either hard or soft wheat containing about 10.5% protein;

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leavening is provided by chemical agents and eggs, if present. McWatters (15) used cowpea flour made from non-decorticated, cream-type peas to replace 10, 20 and 30% of the wheat flour in sugar cookies. The cowpea flour mixtures exhibited dough handling properties and baking characteristics much like the 100% wheat flour control. Baked cookie diameter, height, spread ratio, top grain character, texture and moisture content were not significantly different from the control. Each 10% increment of cowpea flour in the formulation increased the protein content in the baked product by 0.5%. A beany aroma and flavor was noted in cookies made with 30% cowpea flour.

Mustafa *et al.* (12) used a cowpea protein isolate containing 57% protein to replace all-purpose wheat flour (9.17% protein) in cookies. Use of the cowpea protein isolate raised the protein content of the wheat flour to 15 and 20% and resulted in cookies with spread ratios greater than the control. Cookies made from the flour which contained 15% protein were similar in sensory quality to the control and were superior to those made from the flour which contained 20% protein.

Vaidehi *et al.* (16) prepared malt powders from germinated cowpeas and other legumes; the powders were blended with cereal malts and maida, an all-purpose wheat flour, and used in a cookie formulation. The baking performance of the blends was satisfactory, and the overall sensory quality of the cookies was acceptable. Protein content increased from 7.1% in the maida flour cookies to 9.2% in cookies made from 40% cowpea malt powder and 60% maida flour. Mabesa *et al.* (17) also used germinated cowpeas and other legumes to prepare blends of two legume flours to substitute for 100% of the wheat flour in four bakery products. The nutritional quality (relative nutritive value and thiamin, riboflavin, available lysine and methionine content) of cookies, chips, vegetable loaves and noodles was improved substantially by use of the legume flour blends.

Cake-type buttermilk doughnuts prepared with 10, 20 and 30% cowpea meal made from non-decorticated, cream-type peas compared favorably in sensory quality attributes to 100% wheat flour doughnuts (18). Although the batters containing various levels of cowpea meal were well suited to mechanical cutting, dispensing and frying, their open-grain structure contributed to excessive fat absorption during frying. Doughnut quality was improved substantially when cowpeas and other test legumes were used in the form of finely milled flour (19).

Cowpea flour made from dry roasted/dry milled peas was used to replace 40% of the all-purpose wheat flour in cinnamon sweet rolls (13). Finished products were described as having highly acceptable volume, appearance and flavor. The flour was also combined with vegetable oil, partially saturated coconut fat, dextrose and salt to produce a spread product similar to peanut butter. The spread was used to formulate a bar-type pastry product that was reported to be highly acceptable.

COWPEA MEAL/FLOUR IN AKARA AND MOIN-MOIN

Akara and moin-moin are traditional West African foods of which cowpea paste is the principal ingredient. Akara is cooked by frying and moin-moin by steaming. The traditional method for preparing cowpea paste is a time-consuming, labor-intensive, manual process that involves soaking peas in water, wet decortication (seed coat removal), and wet milling. The wet paste must be used within a short period of time to avoid the possibility of microbial spoilage. Recent efforts have resulted in development of technologies to convert cowpeas into a convenient-to-use milled form specifically for use in akara and moin-moin. This type of product needs only the addition of water to make paste, thereby eliminating the soaking, decorticating and milling steps for the consumer.

Onayemi and Potter (20) prepared cowpea powder by a process which involved soaking peas in water, manual decortication, wet milling, dilution with water, mixing with additives (antioxidant, emulsifier, DL-methionine), drum drying, crumbling the dried cowpea sheet into flakes and comminuting into powder. In preparation of moin-moin, unmodified tapioca starch was added to firm the texture of the product. Organoleptic tests indicated that very acceptable moin-moin could be made from freshly-prepared cowpea powder and also from powder that had been stored at 37°C for at least 24 weeks.

Cowpea powder prepared by a process to reduce the typical beany flavor was evaluated for its potential usage in moin-moin (11). Powder preparation involved soaking peas in water adjusted to pH 2, 4 or 6, manual decortication, washing, blanching, grinding to puree, drum drying, grinding of flakes and sieving. Only cowpea powder produced from the pH 6 treatment was used in moin-moin preparation. The consistency of uncooked moin-moin made from several cowpea powder formulations was firmer than the traditionally-prepared product. However, texture and mouthfeel scores of cooked, powder-based products were not significantly different from the traditional product. Flavor and overall acceptance scores for moin-moin made from cowpea powder were significantly lower than for the traditional product. The authors indicated that a more beany-flavored powder would have been more desirable for use in moin-moin, where a beany flavor is preferred.

Village-scale industries have been described as the mechanism providing the greatest opportunity for increasing the availability of high protein legume foods in developing countries which depend upon legumes as dietary staples (21). Developmental projects which have focused on milled products for use in Africa emphasized the use of locally grown grains (22) and mechanical means of decortication and reduction of seed size (23,24). Decortication was accomplished by a dry method (abrasion) so that storage problems associated with flour made by wet milling could be avoided.

Although cowpea meal and paste can be prepared from cream-type peas that can be milled without seed coat removal (25), cultivars that require decortication are more commonly available than the cream type. Conditions which have a significant effect on akara-making quality of cowpea meal include particle size distribution (26), water:solids ratio (27,28) and the temperature at which peas are stored (29). In studies to improve efficiency of decortication by dry mechanical abrasion, a pre-decortication treatment which consisted of wetting-conditioning-drying was found to be effective; however, the temperature used for the drying step affected certain paste characteristics and akara-making quality (30,31). Recommended processing steps that achieve high decortication efficiency while maintaining functionality of cowpea meal in akara preparation were summarized by Chinnan *et al.* (32) and are as follows: (i) adjust the moisture content of a batch of cowpeas to 25% by adding water; (ii) equilibrate at ambient temperature for 30 min with occasional stirring; (iii) dry the peas in a hot air dryer at a temperature of 60–70°C until the final moisture content of the seeds is approximately 10%; (iv) decorticate the peas in a dry decortication mill such as a PRL-type abrasive decorticator or an Engelberg rice polisher; (v) aspirate the loosened seed coats in a seed cleaner; and (vi) grind the seeds in an impact mill fitted with a 1.0-mm opening mesh screen. Meal processed by this method and hydrated to a 58–60% moisture content results in paste with appropriate density, volume and viscosity, and produces akara with highly acceptable organoleptic quality.

COWPEA MEAL/FLOUR IN EXTRUDED PRODUCTS

Extrusion cooking is widely used to produce texturized products such as ready-to-eat breakfast cereals, snack foods and pet foods. Interest in the extrusion processing potential of cowpea derivatives has developed because of their superior protein quality as compared to the cereal and tuber flours normally used in this type of process (33). Cowpea meal adjusted to moisture contents of 20, 30 and 40% and extruded at barrel temperatures of 150, 175 and 200°C produced extrudates with highly varied textures and physical properties (34,35). Depending upon the particular combination of process conditions employed, end product textures ranged from brittle/expanded to tough/chewy to bready/gummy. The protein quality of the cowpea extrudates was equal to that of cowpea paste cooked by steaming or frying (33).

Pham and Del Rosario (36,37) used flour made from cowpeas and several other legumes to study the effect of extrusion conditions on certain protein properties and on the amount of available lysine, total and reducing sugars. Process conditions of temperature, screw speed, moisture content and pH had significant effects on nitrogen solubility and water absorption capacity; the extent of change in these properties was dependent upon the protein content of the starting material. Retention of available lysine in extrudates could be maximized by selecting the combination of process conditions which minimized the amount of total and reducing sugar produced and made available for potential reaction with lysine.

COWPEA MEAL/FLOUR IN MEAT PRODUCTS

Interest in extension of meat products with legume and oilseed derivatives is based primarily upon the potential of reducing product cost. Soy protein products with a fiber-like character or coarsely milled soy grits may be used in extended or simulated meat products. Because cowpea fiber products are not available and may not be economically feasible to manufacture, extension of ground meats with cowpea has focused on meal, which is simple to produce. Studies have shown that extending ground beef with cowpea and other seed meals increased cooked yields and water retention properties of beef patties (38,39). Extended patties were similar to all-beef controls in specific volume and were more tender, requiring less force to compress and shear. The organoleptic quality of extended patties compared favorably with the all-beef product if the legume meal was used at a low level (5%). Steam treatment of the meal prior to incorporation in the meat formulation helped to reduce its beany aroma and flavor.

OTHER FOOD USES OF MILLED COWPEA

For cultures which utilize fermented foods in their diets, the potential for using a variety of legumes for this purpose is of interest. Zamora and Fields (40,41) allowed cowpeas to undergo natural fermentation for four days at 25°C; fermented peas were dried, milled into flour and used as an ingredient in soup. Fermentation produced an increase in the relative nutritive value, limiting amino acids and riboflavin content; niacin, trypsin inhibitor, and raffinose were reduced by fermentation. The need for process modifications to eliminate the acid flavor of the soup, which was disagreeable to some consumers, was indicated.

Schaffner and Beuchat (42) fermented aqueous extracts of cowpeas and other legume seeds with several species of lactic acid bacteria to produce yogurt-like products. In a companion study, the extracts were frozen after fermentation, freeze-dried, milled to powder and evaluated for functionality in model system tests (43). Studies showed that cowpea powder was similar to commercial cultured buttermilk powder in color and water adsorption capacity; was superior to the commercial product in emulsion capacity, foam capacity, and foam stability; was less viscous than unfermented controls but more viscous than the commercial product; and contained less soluble nitrogen than the commercial buttermilk powder or unfermented cowpea products. In addition to biological methods, chemical treatments have been shown in model system tests to modify the physicochemical environment of cowpea seed components and to alter their functional properties (44,45).

Germination has been used to improve nutritional quality and digestibility of legumes and would also be expected to modify functional properties. Mabesa and Novero (46) prepared cowpea flour from germinated cowpeas and other legumes and, using model systems, found that water absorption and adsorption capacities increased while gelation capacity decreased as a result of germination.

In summary, several food systems have been utilized to assess functional characteristics of milled cowpea products. Although some modifications in process conditions or product formulations may be warranted in order to optimize certain functional properties or improve end product quality, the successful performance of cowpea flour in these applications demonstrates potential outlets for expanding the utility of this important legume.

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