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Milling and Use of Okra Seed Meal at the Household Level[1]

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ABSTRACT

Okra seed meal was produced at the household level by grinding seed in a corn seed mill, and sieving to remove most of the seed coat. The meal of about 33% protein and 32% oil was then used in various proportions as a substitute for wheat flour in cookies, cupcakes, sweet bread rolls and typical bread. Okra seed meal slowed the rising of dough in some cases, increased color, and added moisture and an unusual flavor, but was quite acceptable at substitution levels ranging from 25 to as much as 100% in some products. A vegetable curd made by extracting the protein of seeds with water and precipitating with magnesium sulphate was attractive and good-tasting. Thus, okra seeds serve as a potential new grain crop for the tropics.

INTRODUCTION

The improvement of nutrition in the tropics is a complex problem related to socioeconomic questions, as well as foods available and the knowledge of how to use them. One potential seed source, rich in protein and oil, and of great promise throughout the tropics is okra, *Abelmoschus esculenta* Moench. Okra is well distributed throughout the tropics, where it is used chiefly as a vegetable for its immature pods, or, rarely, for its leaves as spinach. From a nutritional standpoint, the richest part of the okra plant is the dried seed. Widespread utilization of the seed as an oily meal to replace flour would reduce dependency on imported wheat in some countries, as well as increase the nutritional value of products made from a composite flour of okra and wheat.

There are only fragmentary accounts of the use of okra seed as a food. The authors have not been able to find a detailed account of its use under either conditions of primitive or advanced agriculture.

Considerable interest was expressed in the use of okra as an oil seed in the United States from about 1940–1950. Techniques for seed production in Louisiana, and yields of seed were investigated by Miller (6). Optimum spacing was about 30 cm between plants in rows about 1.25 m apart. Yields per hectare ranged from 80 to 1,600 kg, with oil contents from 14.8

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to 16.9%. Crushing mills used for the extraction of cottonseed oil proved satisfactory for okra seed. Oils extracted by solvents and hydraulic pressure were acceptable substitutes for cottonseed oil as a cooking oil and for the production of oleomargarine (2). Protein in the seeds was 21.50% on a dry weight basis, and oil content was 18.62%. The oil was reported by Clopton et al., (1) to contain about 32% unsaturated fatty acids.

The protein of okra seed was at first considered only a by-product in the production of oil. However, attention has been focused on the use of the protein as a principal product by Karakoltsides and Constantinides (5). The amount of protein was found to be about 20.6%, with about 20% lipids. Calcium, iron, niacin and vitamin E levels were higher in okra seed than in soybean. On the other hand, thiamine and riboflavin levels were lower. Amino acid studies of the protein revealed methionine to be the first limiting amino acid, present at about 60% of reference protein level. Gossypol contents of the seed were not considered high enough to be a problem in human diets. This suggests that okra seed protein would be most useful blended with protein from cereal grains that would complement the nutritional imbalance.

Karakoltsides and Constantinides (5) also reported that okra seed protein supported rat growth as well as casein did and much better than did soybean protein. In the same study, okra seed meal was used as a substitute for wheat flour in baking bread. When 5% of the wheat flour was replaced by okra seed meal, a highly acceptable conventional bread was produced.

In these studies the interest lay in producing okra meal by simple household tools and appliances, and in finding new uses for okra meal.

MATERIALS AND METHODS

After several preliminary attempts to produce okra meal at the household level, the following technique was used: Dried okra seeds (var. Clemson Spineless) were ground finely with a home corn seed grinder consisting of two burred, circular metal plates, one of which was hand-turned. The broken seeds were then screened by hand through a household sieve of approximately 16 mesh (spaces 1.5 × 1.5 mm), followed by use of a sieve of approximately 25 mesh (1 mm spaces). Variations in grinding and sifting techniques were tested.

The protein content of the okra seed, the meals produced, and two fractions of the seed, hulls and kernel (separated by hand) were measured. The percent N content was determined by the microkjeldahl method and protein content was calculated by multiplying percent N by 6.25.

The oil content was measured upon extraction from the seed or product with petroleum ether in Butt-type extraction apparatus (3).

The protein rich meal produced was then tested with simple household recipes as follows:

Cookies. 37.5 g vegetable lard, 50 g sugar, 100 g flour (control, 50, 75, and 100% okra meal), 0.25 g salt. Mix and sieve flours with sugar and salt, add the flour to the lard gradually to obtain a heavy dough. Form into balls and place them on a greased cookie sheet, and flatten them. Bake at 350° F (177° C) for 20 to 25 min.

Cupcakes. 50 g batter, 87.5 g sugar, 4 ml vanilla extract, one egg yolk (about 25 g), 55 ml milk, 68 g flour (control, 50, 75, and 100% okra meal), 1.8 g baking powder, 0.6 g salt, one egg white (about 25 g). Soften butter and blend it with sugar until smooth, mix in beaten egg yolk and vanilla extract, sieve flour, baking powder and salt together. Add slowly the flour mixture and the milk. Mix in egg white and stir until smooth. Place batter in greased muffin tins. Bake at 350° F (177° C) for 20 to 25 min.

Sweet bread rolls. 12.5 g butter, 22 g sugar, one-half egg (about 25 g), 55 ml water, 200 g flour (control, 50% okra meal), 3.5 g baker's yeast, 0.25 g salt. Add a little sugar to warm water, and mix in yeast. After 10 min add the remainder of the sugar, the salt, the egg, and the butter. Mix well. Add sufficient flour to make a dough. Knead dough, place over warm water and let rise until the volume is doubled. Roll out the dough to 0.5 cm thickness. Butter the dough lightly. Sprinkle brown sugar on surface. Grease a cookie sheet with butter. Roll the dough up, and cut into pieces 2.5 cm thick and place on sheet. Sprinkle with brown sugar. Let rise to about 150% of original volume. Bake in preheated oven at 475° F (244° C) for 15 to 20 min.

Typical bread. 6 g butter, 5 g sugar, 40 ml warm water, 100 ml milk, 300 g flour (control, 50% okra meal), 3.5 g baker's yeast, 3 g salt. Add yeast to warm water, stir in cooled scalded milk, add melted butter, salt, and sugar, blend, add slowly the sifted flour and beat until dough is smooth and elastic. Continue adding more flour until dough is stiff. Sprinkle flour on mixing board. Knead dough on mixing board, maintaining a layer of flour on the dough. Fold dough repeatedly. Add flour as needed until dough is no longer sticky. Place dough in greased bowl and grease top. Place over warm water until volume is almost double. Test until finger indentations remain in dough. Punch dough to remove gas, and shape into a smooth ball. Squeeze to divide the ball, and form loaves. Place in greased pan, seam down, cover and let rise in warm place until almost double in volume. Bake at 375° F (191° C) for about 45 min.

Vegetable curd. One hundred g of dried seeds were soaked overnight in water. They were ground finely the following morning in about three volumes of water with a household blender. The resulting mixture was filtered through a cotton cloth. The cloth was squeezed to remove a maximum of liquid. This liquid was heated to 90° C for 1/2 hour. Then

1 g $MgSO_4$ (commercial Epsom salt) was added and stirred in. The cooled mixture was then filtered through cheese cloth. The precipitate was pressed between blocks of wood with weight to remove more liquid. This curd was then salted and taste-tested, and protein and oil content were determined.

The prepared products were compared to controls by informal ratings. Taste and acceptance were determined through an irregular group of laboratory and office personnel.

RESULTS

Grinding and sieving okra seeds effectively separated the kernels from the hulls. While the kernels tend to break into small pieces when ground, the hulls are resilient, and leave the grinder as larger pieces. Fine grinding results in recovery of a greater portion of the kernel and its protein than course grinding (table 1). The meal recovered by sieving approximates the protein content of kernels separated from the hulls by hand. At the

TABLE 1.—*Effects of grinding and separating techniques on content of protein of okra seed and meal fraction*

Grinding technique	Fraction	Whole seed in fraction	Protein in fraction	Whole seed protein in meal	Oil in fraction
		%	%	%	%
None	Whole seed	100	17.4	—	17.7
	Hulls only	53	6.6	15.6	2.4
	Kernels only	47	35.6	84.4	35.1
Coarse grinding	Residue	88	16.6	—	—
	Meal	12	33.2	20.9	—
Medium grinding	Residue	69	13.9	—	—
	Meal	31	30.4	50.0	—
Fine grinding	Residue	60	13.5	—	—
	Meal	40	32.7	61.7	32.0

finest grinding, about 40% of the protein was not recovered in the sieved meal. Much was recovered by regrinding and resieving the residue. The finely sieved flour (25 mesh screen, particles of less than 1 mm) approximated wheat flour in appearance but was somewhat sticky due to its high oil content (about 32%).

All of the baked products using okra meal rated acceptable as food and compared favorably with the controls (table 2). Okra meal imparted an unusual odor, a brown color, and a unique taste to all products. These characteristics were judged acceptable or attractive. Flavor and odor were masked in cookies and cupcakes but more pronounced in breads.

Okra meal made the mixture or dough sticky and more difficult to mix or knead. Doughs with a high percentage of okra flour tended to "fall." This resulted in baked products slightly more dense than the controls.

The attractiveness of cookies was slightly reduced as the percentage of okra meal increased. The flavor was improved, however. The appearance of cupcakes was slightly damaged by okra meal; the taste improved only at the 50% level. Sweet bread rolls made with okra meal were also less attractive, but of equal flavor. Okra flour was judged suitable for these baked products.

The bread baked from 50% okra flour was heavier than typical white bread. The crumb was more dense, but the bread was moist. This bread compared favorably to other types of dark bread, such as whole wheat, cracked wheat, and rye bread. It was judged inferior to white bread by persons accustomed to and preferring white bread, but was rated equally acceptable as compared to dark breads by persons that prefer such breads.

TABLE 2.—*Summary of characteristics of baked products, using okra meed meal*

Product	Okra meal	Ease of kneading or mixing	Rising of dough	Tendency to "fall"	Tendency for overbrowning	Rating of appearance[1]	Rating of taste[1]
	%						
Cookies	None	Normal	Normal	None	Minimum	3	3
	50	Slightly difficult	Poor	None	Slight	4	3
	75	Slightly difficult	Poor	None	Medium	3	4
Cupcakes	None	Normal	Normal	Minimum	Very slight	3	4
	50	Normal	Normal	Slight	Very slight	3	4
	50	Sticky	Normal	Medium	Slight	3	3
	100	Very sticky	Normal	Pronounced	Slight	2	3
Sweet bread rolls	None	Normal	Normal	Minimum	Slight	3	3
	50	Sticky	Slow	Minimum	Medium	2	3
Typical bread	None	Normal	Normal	Minimum	Slight	3	3
	50	Very sticky	Slow	Minimum	Strong	2	2

[1] Rated as compared to control: 1 = very much inferior; 2 = slightly inferior; 3 = equal; 4 = slightly better; 5 = much better than control.

Production of vegetable curd from okra seed was as easy as the production of tofu from soybeans. The finely ground mixture of seeds and water separated readily by filtration to a grainy residue and an off-white vegetable milk. Precipitation began at 90° C and was increased by the addition of $MgSO_4$. The mixture filtered through cheese cloth yielded a transparent yellow whey and a cream-colored curd. By pressure, this was further dried and molded into a cheese. The protein content of this cheese (dry weight basis) was 35.6%; the total lipid content (dry weight basis) was 41.8%.

The okra cheese so produced had a creamy appearance, a smooth texture, a very slight odor, and a pronounced but agreeable flavor similar to tofu from soybean but with a distinctive okra seed flavor. The cheese was rated as attractive and acceptable by persons familiar with tofu. Okra cheese should serve in the same way as *tofu,* as a substitute for conventional cheese in cookery.

DISCUSSION

These tests have shown that an acceptable meal can be made from okra seed with the use of simple kitchen appliances. Hand grinders used in place of the electric home blender make the use of electricity unnecessary. The meal could then be used in a variety of common recipes as a substitute for part of the wheat flour. Or the soaked ground seeds could be used to form a high protein vegetable curd comparable to tofu from soybean, and equally useful as a meat substitute. The fact that these operations can be done at home potentially relieves, at least in part, every small farm family in the tropics from reliance on imported or purchased wheat flour.

A considerable amount of research remains to be done on the agronomic and genetic aspects of okra seed production in both the dry and the hot humid tropics.

Karakoltsides and Constantinides (5) produced a white, western-type bread using only 5% okra flour. Experimental composite flours made into bread in the continental United States seldom contain more than 20% of the flour used as a substitute for wheat flour (4). This proportion is due to certain standards applied to the judgment of acceptability. When one takes into account the many kinds of dark bread made throughout the world, one easily sees how arbitrary the American standards are.

The use of okra seed meal in place of wheat flour could reduce the need for importation of wheat flour. The use of okra vegetable curd could make available a highly nutritious dish at low cost. The production of bread with okra seed meal (high in lysine, low in methionine) and wheat flour should result in a complementing of amino acids that would make the protein of more value than either protein eaten alone.

While this introductory study demonstrates feasibility of okra seed use, complementary studies are necessary including measurement of gossypol content, studies of the shelf life of the meal, and evaluation of the possibility of aflatoxin in the seed produced during the rainy seasons. With appropriate study and development it appears that okra seed could become a new crop for the tropics.

RESUMEN

Semillas secas de quimbombó (*Abelmoschus esculenta*) se molieron en un molinillo de mano usado para maíz y se cirnieron para separar la harina de la cáscara. Esta harina se usó en una variedad de productos horneados, tales como galletas dulces, bizcochitos, panes dulces y pan, sustituyendo parte de la harina de trigo y del aceite. Además, las semillas se

dejaron en remojo por la noche y se desmenuzaron el día siguiente con tres volúmenes de agua en una licuadora casera. La mezcla se filtró con una tela y la "leche" producida se calentó. La proteína se precipitó con sulfato de magnesio y se filtró para obtener una cuajada similar al queso. Se obtuvo una harina de 40% de proteína y 32% de aceite. Todos los productos preparados con esta harina tenían un sabor distinto, pero eran atractivos al comparárseles con productos control hechos con harina de trigo. En algunos casos la masa con harina de quimbombó creció más lentamente y los productos eran más densos, pero suficientemente húmedos. El nivel de harina de trigo quese puede sustituirse varía de 25 a 100%.

La cuajada de quimbombó tiene apariencia atractiva, buen sabor y puede usarse como el "tofu" de la soya. Esto demuestra que la semilla de quimbombó rinde una harina panificable y una cuajada rica en proteínas, por lo cual, el cultivo de esta planta para estos fines, aumentaría el potencial alimentario en las regiones tropicales.

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