COTTONSEED FOOD SUPPLEMENT

Nutritive Value of Bread and Cookies Containing Cottonseed Flour

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Water bread containing 10 parts of cottonseed flour per 100 parts of wheat flour (white) gave significantly higher rates of gain per gram of nitrogen consumed than water bread without the cottonseed flour when fed to young rats at levels furnishing 10% protein. When the effect of the addition of cottonseed flour to bread containing nonfat milk solids was tested, it was found that no significant increase in the nitrogen efficiencies was brought about by the cottonseed flour when the breads were both fed at the same protein level. However, when the breads were fed at the same percentage by weight, the higher protein content of bread containing cottonseed flour brought about significantly higher rates of gain than the same amount of bread without cottonseed flour.

COTTONSEED FLOUR FOR HUMAN CONSUMPTION was available as early as 1876, but has never been very widely employed (*7*). Recent advances in cottonseed processing have led to the production of meals and flours of high nutritive quality and the question arises as to whether the use of these products with wheat flour would increase the protein quality of the resulting baked products. Jones and Divine (*4*) demonstrated that the growth-promoting value of a mixture of 5 parts of cottonseed flour to 95 parts of wheat flour was higher than that of wheat flour alone when fed to rats at a level of 9.1% protein in the ration.

Recently the Bakery Department of the Oklahoma Agricultural and Mechanical College, under contract with the U. S. Department of Agriculture, has developed formulas for the incorporation of cottonseed flour in a variety of baked products. The Bureau of Human Nutrition and Home Economics has tested the protein quality of products made from some of these formulas by feeding them to young rats as a source of protein in an otherwise adequate ration. Complete formulas for a variety of baked foods containing cottonseed flour may be found in a bulletin by Summers, Mead, and Thurber (*7*). A preliminary report of the properties of these foods, including palatability studies, has been presented by Summers and Thurber (*8*), and the results will be published in full elsewhere.

Experimental Work

Weanling male rats were divided into groups of 12 according to litter and body weight. They were housed individually in an air-conditioned room maintained at 80° ± 2°F. and food and water were furnished ad libitum. The animals were weighed weekly and the food intakes determined. Each animal was fed the experimental ration for 28 days.

In two experiments, the protein quality of the following breads containing wheat flour was investigated: experiment I, bread 1, made with white flour and no milk solids, and bread 2, which contained 10 pounds of cottonseed flour (specially prepared commercial cottonseed flour manufactured by the Traders Oil Co., Fort Worth, Tex.) per 100 pounds of white flour; experiment II, bread 3, made with white flour and no milk solids (similar to bread 1, but made at a different time); bread 4, which contained 4 pounds of nonfat milk solids per 100 pounds of white flour; and bread 5, which contained 4 pounds of milk solids and 8 pounds of cottonseed flour per 100 pounds of white flour. (When both milk solids and cottonseed flour were included in the bread, it was necessary to reduce the cottonseed flour to 8 pounds to obtain a loaf of good volume.) In experiment III, the protein quality of (1) cookies containing 27.8 parts of oatmeal to 72.2 parts of pastry flour or (2) cookies made from the same formula, except that 21.5 parts of the pastry flour were replaced with cottonseed flour, was also investigated.

Other ingredients of the ration were salt mixture (*6*) 4 grams; vitamin A and D concentrate (Squibb's Navitol containing 65,000 U.S.P. units of vitamin A and 13,000 units of vitamin D per gram) 0.05 gram; inositol 0.1 gram; choline chloride 0.2 gram; and sucrose to make 100 grams. In experiment I (breads 1 and 2) 3% corn oil was incorporated in all rations and in experiment IIIb 7% cottonseed oil was added to the ration to equalize the fat contents of the three rations containing cookies. The following vitamins were added per kilogram of ration: thiamine hydrochloride, pyridoxine hydrochloride, and nicotinic acid, 5 mg.; riboflavin, 10 mg.; calcium pantothenate (*d*), 25 mg.; *p*-aminobenzoic acid, 300 mg.; α-tocopherol acetate, 25 mg.; 2-methyl-1,4-naphthoquinone, 2 mg.; biotin, 100γ; folic acid, 2 mg.; and vitamin B_{12}, 30γ.

The breads were baked for 25 minutes at 425° F. and the cookies for 15 minutes at 365° F. They were made at Okmulgee, Okla., and shipped to Beltsville, Md. Immediately upon receipt, the breads were sliced, air-dried, and ground in a Hobart mill. The cookies were ground without preliminary drying. The nitrogen content of the ground products was determined by the macro-Kjeldahl method. The nitrogen content of six air-dried samples of whole wheat bread purchased in local stores was also determined, in order to compare nitrogen contents of these breads with those containing cottonseed flour. In each experiment, the protein levels (N × 5.7) were kept constant for one comparison and the bread levels constant for another.

To determine whether the quality of the protein of the breads was enhanced by the addition of cottonseed flour, all breads were incorporated in the rations at levels to furnish 10% protein. To determine the effect upon growth of the higher protein content of the breads containing cottonseed flour, these breads (2 and 5) were also incorporated in the rations in amounts which furnished 10% protein for breads 1 and 4. These amounts of bread furnished 12.5 (bread 2) and 12.4 (bread 5) % protein in the rations. The protein content of the cookies was low; the highest level at which cookie 1 could be fed supplied only 4.7% protein in the ration. When cookie 2 was fed at the same level, the protein content of the ration was 7.5%. In calculating the protein content of the cookies, the factor used for converting nitrogen to protein was 5.7 for wheat, 5.83 for oatmeal, and 5.3 for cottonseed flour (*2*). However, as there is no general agreement as to the factor to be used in such conversions, the results of this study are reported as nitrogen efficiencies (grams gain per gram of nitrogen consumed) rather than as protein efficiencies. For comparison with other results, they may be divided by the factor used in calculating the other data.

Results

The average weight changes, food consumptions, and nitrogen efficiencies (grams gain per gram of nitrogen consumed) for the rats fed the rations containing the various baked products with and without cottonseed flour are shown in Table I. Analysis of variance was used to aid in the interpretation of the results. In experiment I, where no milk solids were added to the breads, the addition of 10 pounds of cottonseed flour per 100 pounds of white flour significantly improved the nitrogen efficiencies, from 2.91 to 5.57. Moreover, animals fed rations containing 86.43% of bread 1 (experiment Ia) grew only 7.4 grams in 28 days while those receiving 86.43% of bread 2 gained 31.3 grams in the same period (Ic) and the grams of food required for 1 gram of gain decreased. These figures indicate that the addition of cottonseed flour of the quality used to bread made with white flour and containing no milk solids significantly improves not only the protein content but also the protein quality of the bread.

In experiment II, the nitrogen efficiency of bread 3 (white flour, no milk solids, and no cottonseed flour) was 3.64, which is not significantly different from the value of 2.91 obtained for the same type of bread in experiment I. When 4 pounds of milk solids per 100 pounds of white flour were added (bread 4), the nitrogen efficiency was significantly improved to 5.94. When both milk solids and cottonseed flour were added (bread 5) and the rations were fed at the same protein level (experiment IIc), the nitrogen efficiency of 6.76 was not significantly different from the value obtained upon the addition of milk solids alone. However, when the higher level of bread was included in the rations, the gains in weight of the animals were increased from 22.1 grams in 28 days (experiment IIb) to 42.6 grams in the same period (IId), while the grams of food required for 1 gram of gain fell to 6.2. These studies show that while the protein quality of bread containing 4% milk solids is not significantly improved by the addition of 8% cottonseed flour, the higher protein content of the loaf brought about by the addition of cottonseed flour is beneficial to the animals.

In experiment III, animals fed the rations containing the oatmeal cookies with and without the cottonseed flour at levels of 4.7% protein failed to gain in weight. Even the group that received the cookies containing cottonseed flour at a level which provided 7.5% protein in the ration showed average gains of only 2.0 grams in 28 days. Jones, Caldwell, and Widness (*3*) found that hard wheat, soft wheat, or rolled oats when incorporated in rations at levels of 7.5% protein and fed to young rats for 42 days allowed gains in weight of 43, 28, and 59 grams, while animals fed cottonseed flour at levels furnishing 10% protein gained 82 grams in the same length of time (*5*). From these results one would expect a mixture of wheat flour, rolled oats, and cottonseed flour fed at a level of 7.5% protein in the ration to give a higher rate of growth than was obtained in the present study. Perhaps the proteins were damaged by the baking temperatures. This supposition could be tested, but as cookies normally contribute very little to the

Table I. Average Change in Weight in 28 Days and Nitrogen Efficiencies of Animals Fed Bread or Cookies with or Without the Addition of Cottonseed Flour

Expt. No.	Type of Diet	Description	Baked Product in Diet, %	Protein in Diet[a], %	Change in Weight, G.	Food Intake, G.	G. Food/ G. Gain	Nitrogen Efficiency[b]
I	Breads without milk							
a	Bread 1	No MS[c], no CSF[d]	86.43	10	+ 7.4	147.4	19.9	2.91
b	Bread 2	No MS, CSF added	69.06	10	+19.2	196.5	10.2	5.57
c	Bread 2	No MS, CSF added	86.43	12.5	+31.3	225.1	7.2	6.27
II	Breads without and with milk							
a	Bread 3	No MS, no CSF	95.33	10	+10.7	165.8	15.5	3.64
b	Bread 4	MS	89.05	10	+22.1	209.6	9.5	5.94
c	Bread 5	MS and CSF added	71.63	10	+26.1	219.9	8.4	6.76
d	Bread 5	MS and CSF added	89.05	12.4	+42.6	264.7	6.2	7.32
III	Cookies							
a	Cookie 1	Oatmeal and white flour	95.65	4.7	− 4.9	104.5		−5.70
b	Cookie 2	Oatmeal, white flour, and CSF	60.56	4.7	− 0.9	112.3		−0.94
c	Cookie 2	Oatmeal, white flour, and CSF	95.65	7.5	+ 2.0	130.9	65.4	1.17

[a] See text for factors used in calculation.
[b] Nitrogen efficiency = g. gain/g. nitrogen consumed.
[c] Milk solids.
[d] Cottonseed flour.

daily protein supply of individuals or of a population, the point hardly seems to warrant further investigation.

The nitrogen contents of the two air-dried breads containing cottonseed flour were 2.54 and 2.45%. Air-dried samples of six whole wheat breads purchased in local markets contained 2.25, 2.48, 2.51, 2.41, 2.27, and 2.32% nitrogen. As both the color and the nitrogen content of the breads containing cottonseed flour more nearly approached that of whole wheat bread than white bread, a comparison of the protein quality of the two breads would perhaps be of value. The results of the present study show that the incorporation in white bread of either 10 parts of cottonseed flour or 4 parts of milk solids will improve, to about the same extent, the protein quality as measured by rat growth. Where protein supplies are limited and where milk solids are not available, cottonseed flour of the quality used in these experiments might prove useful to enhance the protein quality of bread.

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Tailor-Making an Insecticide; Potential Market for Chemicals as Rodent Repellents

CHEMICAL STRUCTURE–ACTIVITY RELATIONSHIP

Chemical Structure of a Series of Organic Sulfites And Its Toxicity to the Two-Spotted Spider Mite

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Following the discovery by this laboratory that 2-chloroethyl dodecyl sulfite is highly toxic to the two-spotted spider mite (*Tetranychus bimaculatus* Harvey), related unsymmetrical sulfites were studied. The relationships between chemical structure and toxicity to the two-spotted spider mite are discussed. This study led to the conclusion that the sulfite radical is the "toxic" group and the rest of the molecule serves to modify chemical and physical properties. Substitution of aryloxy radicals for a portion of the long-chain alkyl radical produced a flexible new series of sulfites which made it possible to tailor a compound of optimum activity which is free from the undesirable side effects often associated with insecticides. The effect of size, shape, and location of various substituents on the toxicity to two-spotted spider mites is discussed.

Esters of sulfurous acid were mentioned as insecticides as early as 1929 by workers of I. G. Farbenindustrie. Two esters, bis(2-chloroethyl) sulfite glycol sulfite, were disclosed as being toxic to grain weevils (*3*). Hechenbleikner (*2*) later described several sulfites as being toxic to mites, aphids, and thrips. His data indicate that dialkyl sulfites such as dilauryl sulfite and di-2-ethylhexyl sulfite are especially toxic to mites, and to a lesser extent to aphids.

The writers' interest in the organic sulfites began as a result of the discovery that 2-chloroethyl *p*-chlorobenzenesulfonate is toxic to the two-spotted spider mite (*Tetranychus bimaculatus* Harvey). Among the chemicals tested in following up this lead was 2-chloroethyl dodecyl sulfite (*1*). This compound exhibited an LD_{95} of about 150 p.p.m. It was roughly eight times more toxic to two-spotted spider mites than the sulfonate and over thirty times as toxic as the compounds of the prior art, as shown in Table I.

It is obvious from Table I that in the sulfite series toxicity to mites is greatly affected by the nature of the organic radicals. A program was initiated to study the relationships between structure and activity in this series as the first step in the development of a practical control for mites.

2-Chloroethyl dodecyl sulfite is an unsymmetrical ester of sulfurous acid. This class of compounds can be represented by the generalized formula

$$R{-}O{-}\overset{\overset{\displaystyle O}{\|}}{S}{-}O{-}R'$$

Both R and R′ can be varied to produce a large number of compounds with any