randomly selected flours showed that the differences between flours tested jointly against experimental error were statistically significant at the 5% level, indicating again the presence of some factor in the dough lipid which could influence x and y production over and above simple artifact formation.

Discussion

The observations made in these experiments thus deserve consideration, and the possibility that methoxylation by BF_3 may be enhanced by some oxidation mechanism acting on the dough oil must still be left an open question. If the agreement between our early results is regarded as significant, and if the effect of air and oxidants on x and y yield as the flour ages is taken as evidence of a change in the reactivity of the flour lipid to oxidative reactions, then it is of interest to consider briefly our earlier suggestion of the existence of a reversible lipid oxidation reaction.

While lipids have been found to play a part in the oxidative reactions involving protein —SH groups (7) and have been said to compete with —SH for available oxygen in the dough (8), the importance of lipid peroxides in dough oxidation has been doubted in view of the small quantity and low reactivity of the hydroperoxides found experimentally (9). The existence of a reversible lipid oxidation involving a transient oxidation stage (envisaged as a substrate in the BF_3 methoxylation reaction other than the artifact reaction) would explain the lack of peroxide activity in dough lipid during oxygen transfer between oxidant and protein —SH. Even though Privett has obtained evidence of the possible existence of an oxidation stage prior to stable hydroperoxide formation (10), much work remains to be done before the reversible oxidation mechanism we have proposed can be proved or disproved. A method of detection more specific than the BF_3 reaction will be required and the transient nature of such intermediates will add to the experimental difficulties. However, from the limited evidence presented here the implications of such a study can be seen to be of great interest both in and beyond the field of cereal chemistry which is our immediate concern.

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Further Studies of Degossypolized Cottonseed Meal as a Source of Plant Protein in Rabbit Feeds

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Abstract

Degossypolized cottonseed meal was fed to mature female rabbits throughout four successive litters, using a split-plot randomized block design. When used as a replacement for soybean meal, at levels of 4, 7, 10 and 13% of the diet, no significant diet responses were found in the analyses of total litter weaning weight, average individual weaning weight, percentage mortality, number weaned, or feed conversion. However, block and litter effects on litter weight were significant, suggesting genetic differences, and the means for litter weights and mortality suggested an adverse effect at the 10 and 13% levels. Results indicated that at levels of 4 and 7% degossypolized cottonseed meal may serve as a satisfactory substitute for soybean meal in the rabbit diet.

PREVIOUS STUDIES by Casady et al. (1962) showed that degossypolized cottonseed meal, when used as a replacement for soybean oil meal, at levels of 3, 5, 7, and 9% of the rabbit diet, produced no significant diet responses in the analyses of average individual weaning weight per litter, percent mortality in young rabbits, or feed conversion. However, the linear and quadratic responses of total litter weaning weight to additional cottonseed meal were significant. The significant quadratic regression of unadjusted total weaning weight on percentage of cottonseed meal was caused by better growth with the 3 and 5% diets. There were, in addition, indications of a depressing effect on total litter weaning weight at the 7 and 9% levels.

The purpose of this experiment was to obtain more data using levels of cottonseed meal which overlapped

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TABLE I

Composition and Chemical Analyses[a] of Rabbit Diets

Ingredient	Diets				
	1 (Control)	2	3	4	5
	(%)	(%)	(%)	(%)	(%)
Sun-cured alfalfa meal	40.0	40.0	40.0	40.0	40.0
Soybean meal (expeller)	18.0	14.0	11.0	8.0	5.0
Linseed meal (expeller)	4.0	4.0	4.0	4.0	4.0
Barley	18.5	18.5	18.5	18.5	18.5
Oats	4.0	4.0	4.0	4.0	4.0
Wheat mixed feed (millrun)	15.0	15.0	15.0	15.0	15.0
Salt (NaCl)	0.5	0.5	0.5	0.5	0.5
Degossypolized cottonseed meal[b]	0.0	4.0	7.0	10.0	13.0
Crude protein	20.49	20.43	20.90	21.08	21.09
Ether extract	3.26	3.24	3.16	3.06	2.69
Crude fiber	14.33	14.61	14.94	15.15	15.66
N.F.E.	46.95	46.82	46.23	45.91	46.06
Ash	6.89	6.86	6.69	6.76	6.55

[a] Determined on an air dry basis.
[b] Free gossypol 0.016%; total gossypol 0.79%. Supplied by San Joaquin Cotton Oil Company, Los Angeles, Calif.

TABLE II

Diet, Block, and Litter Least Square Means and Standard Errors

Diet	Average individual weight per litter		Total litter weaning weight		Feed conversion [b]	Mortality	No. weaned
	Unadjusted	Adjusted [a]	Unadjusted	Adjusted [a]	Adjusted [a]	Adjusted [a]	Adjusted [a]
	(lb)	(lb)	(lb)	(lb)		(%)	
1	3.86±0.09	3.86±0.09	21.63±1.57	21.34±0.92	3.22±0.12	16.81	5.58±0.20
2	3.76±0.12	3.76±0.12	19.70±2.02	21.78±1.21	3.37±0.16	19.20	5.75±0.26
3	3.71±0.12	3.72±0.12	22.04±2.02	20.77±1.19	3.41±0.16	15.10	5.48±0.25
4	3.64±0.09	3.64±0.09	19.69±1.53	19.19±0.90	3.56±0.12	22.30	5.16±0.19
5	3.76±0.11	3.73±0.12	18.55±1.88	20.81±1.13	3.13±0.15	24.31	5.54±0.24
Blocks							
1	3.95±0.11	3.94±0.11	22.96±1.08	25.38±1.81	3.32±0.14	18.12	5.74±0.23
2	3.66±0.10	3.65±0.10	20.18±1.06	21.10±1.80	3.56±0.14	17.92	5.46±0.23
3	3.48±0.16	3.49±0.16	19.58±1.62	15.27±2.68	3.22±0.21	19.43	5.39±0.35
4	3.54±0.12	3.55±0.11	18.58±1.18	15.39±1.95	3.45±0.15	18.09	5.26±0.25
5	3.81±0.11	3.81±0.11	21.68±1.07	22.36±1.83	3.23±0.14	16.58	5.72±0.23
6	4.00±0.11	4.00±0.10	21.70±1.05	22.49±1.79	3.26±0.14	18.46	5.43±0.22
Litters							
1	3.65±0.08	3.66±0.08	18.97±0.79	16.82±1.30	3.53±0.10	18.13	5.22±0.17
2	3.78±0.08	3.77±0.08	21.16±0.79	21.62±1.36	3.27±0.10	18.11	5.52±0.17
3	3.87±0.09	3.87±0.09	22.22±0.92	23.28±1.57	3.32±0.12	18.07	5.65±0.19
4	3.66±0.07	3.66±0.08	20.76±0.66	19.60±1.30	3.24±0.09	18.09	5.61±0.11

[a] Adjusted for unequal frequencies and rabbit feeding days. In this type of analysis standard errors will differ among diets.
[b] Pounds of feed to produce a pound of weight at weaning.

those of the previous study and to try and verify growth stimulation at low levels and depressing effects of higher levels.

Materials and Methods

Design

A split-plot randomized block design was followed. Thirty mature New Zealand White does were bred to 6 unrelated bucks, forming 6 half-sib blocks of 5 does each. The 5 does within each block were randomly assigned to one of the 5 diets which were fed to 4 successive litters. Where sisters were available they were assigned to different blocks and received different diets.

Feeding

Five diets were used, 1 control and 4 experimental (Table 1). The basic stock diet in use at the U.S. Rabbit Experiment Station served both as the control and as the basis of the other 4 diets. Does received the various diets throughout pregnancy and lactation until the young were weaned. Diets were available to the young from the time they left the nest box at approximately three weeks of age, until weaning. All diets were fed free choice.

General

All animals were housed in all-metal, self-cleaning hutches equipped with automatic waterers. Does were rebred 38 to 39 days following parturition and palpated for pregnancy 12 days following breeding. They were weighed when placed on test and when each of their litters was weaned. Young were weighed, weaned and removed from experiment at 56 days of age. As far as possible, litters were equalized at 8 young each within three days following parturition. Illness of does and young, and any treatments administered, were recorded. All animals that died on test were weighed and autopsied. Feed consumption was determined from parturition to weaning.

Analysis of Data

Results were evaluated on the basis of total litter weaning weight, average individual weaning weights, total mortality, enteritis mortality, number weaned, and feed conversion as determined by the amount of feed required to produce a pound of weight at weaning.

The method of analysis was analogous to that employed by Casady et al (1962) except that, owing to a number of missing values, least squares methods were used. The analyses of variance for total weight, average weight, total mortality, enteritis mortality, feed conversion and number weaned were calculated both adjusted and unadjusted for covariance of rabbit feeding days. The least square diet, block and litter means for these traits are listed in Table II.

Results and Discussion

No significant difference between diets were indicated for any of the traits considered. Further, there were no significant linear or quadratic responses to increased levels of cottonseed meal for any of the traits. This is somewhat surprising in view of the significant linear and quadratic responses of unadjusted total litter weight in the previous experiment. The unadjusted total litter weight is related to the number weaned and the variation in number weaned was much greater in the first experiment than it was in this experiment. The range for number weaned was 1.4 and 0.94 for the first and second experiments, respectively.

The only main effects which were significant in either the adjusted or unadjusted analyses for litter weight were those for blocks and litters. Also, there was a significant block × diet interaction. Since the blocks (paternal half-sib families) were on treatment at the same time, the significant block differences for average litter weight could be due to genetic differences. Also, the significant block × diet interaction might arise from a genotype environment interaction.

Although the analyses showed no significant differences between diets, the means for total litter weight, average litter weight and mortality suggest an adverse effect of cottonseed meal at levels exceeding 7% of the diet. Determining whether these apparent differences are real would require a more extensive study with possible refinements in data collection and analytical procedures. However, these results substantiate those of the previous study where depressing effects were noted at levels of 7 and 9% of the diet. It would thus appear that caution should be used in utilizing cottonseed meal as a protein supplement at levels exceeding 5–7% of the rabbit diet.

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