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The Comparative Value of Heated Ground Unextracted Soybeans and Heated Dehulled Soybean Flakes as a Source of Soybean Oil and Energy for the Chick

L.B. CAREW JR.,[1] F.W. HILL,[2] and M.C. NESHEIM, Department of Poultry Husbandry, New York State Agricultural Experiment Station, and Graduate School of Nutrition, Cornell University, Ithaca, New York

Experiments were conducted to evaluate heated unextracted soybean fractions as sources of soybean oil and protein for the growing chick. Heated dehulled unextracted soybean flakes produced growth rate and feed efficiency equal to that obtained with the combination of soybean oil meal and degummed soybean oil while heated ground unextracted soybeans were less satisfactory in this respect. The poorer results obtained with ground unextracted soybeans were shown to be related to a poorer absorbability of the oil in them. Flaking the soybeans markedly improved the absorbability of the oil by the chick, probably by causing a greater disruption of cellular structure than was obtained by the grinding of the soybeans. The metabolizable energy of ground unextracted soybeans was substantially less than that of unextracted soybean flakes. Most of the differences in metabolizable energy were accounted for by differences in absorbability of the oil.

Soybean hulls at a level equivalent to that contained in soybeans were found to have no effect on growth rate and only a slight effect on feed efficiency. Autoclaving soybean oil did not lower its value for the chick. The relationship between the poorer growth obtained with ground unextracted soybeans and the low absorbability of the oil in them was discussed.

To obtain maximum efficiency in the use of unextracted soybean products in chick rations, some such means as flaking must first be employed to increase the availability of the oil.

HIGHLY unsaturated vegetable oils are excellent sources of energy for the chick and have also been shown to increase rate of growth in chicks (1,2). Low dietary levels of soybean oil have been reported to improve growth rate by several workers, using practical or semipurified diets (3,4,5,6), while studies with purified diets have shown that approximately 10% soybean oil is needed for maximum growth response (2).

The work to be described was undertaken to determine the ability of unextracted soybean products to serve as a source of both soybean oil and protein for the chick. In a preliminary report (7) heated dehulled unextracted soybean flakes were shown to be as effective as the combination of soybean oil meal and degummed soybean oil in semipurified chick diets, based on measurements of growth rate of chicks and efficiency of feed utilization. Renner and Hill (8) reported a lower metabolizable energy value for heated ground unextracted soybeans than expected from the energy values that were previously determined for soybean oil and soybean oil meal. This was shown to result from incomplete utilization of the oil in the soybeans and provided an explanation of the failure of heated ground soybeans to stimulate growth in earlier studies in this laboratory.

Further studies on the growth-stimulating effect and metabolizable energy values of unextracted soybean products in chick diets are presented in this paper.

Materials and Diets

The two semipurified reference diets used in these experiments are shown in Table I. One (I) is the low-fat basal diet (1.5% fat) used as the negative control, and the second (II) is the soybean oil-supplemented diet (14.3% fat), which served as the positive control. The diets were based largely on glucose and soybean oil meal and were supplemented with adequate amounts of all vitamins and minerals known

TABLE I

Composition of Low-Fat Basal and Soybean Oil Reference Diets

Ingredients	Diet I	Diet II
	Low-fat basal diet[a]	Soybean oil diet[a]
	%	%
Glucose (Cerelose)	46.6	23.8
Soybean oil meal (50% protein)	41.0	48.7
Soybean oil, degummed	......	12.8
Constant ingredients	12.4	14.7
Dried fish solubles	0.50	0.60
Corn distillers dried solubles	2.00	2.38
Dried whey	2.00	2.38
Corn oil or soybean oil	0.50	0.60
DL-Methionine	0.15	0.18
Glycine	0.50	0.60
Limestone	1.83	2.18
Dicalcium phosphate	1.30	1.55
Iodized salt	0.60	0.71
Manganese sulfate	0.03	0.04
Chromium oxide mix (30% Cr_2O_3)	1.00	1.19
Mineral mixture[b]	1.15	1.37
Vitamin mixture[b]	0.82	0.95
Diphenyl-p-phenylenediamine	0.01	0.01
Butylated hydroxytoluene	0.01	0.01

[a] All proportions are on a dry-matter basis.

[b] Mineral and vitamin mixtures supply, in mg./100 g. of basal diet: 870 KH_2PO_4, 240 $MgSO_4$, 0.3 NaI, 28 $FeSO_4 \cdot 7H_2O$, 0.8 $CuSO_4 \cdot 5H_2O$, 6.3 ZnO, 0.17 $CoCl_2 \cdot 6H_2O$, 0.83 $Na_2MoO_4 \cdot 2H_2O$, 0.022 Na_2SeO_3, 1.0 thiamine, 1.0 riboflavin, 4.0 calcium D-pantothenate, 2.0 pyridoxine HCl, 8.0 niacin, 0.3 folacin, 0.3 menadione, 0.04 biotin, 0.005 vitamin B_{12}, 1.0 chlortetracycline, 147 choline chloride; 3.3 I.U. alpha-tocopheryl acetate, 1,000 I.U. vitamin A, 150 I.C.U. vitamin D_3.

[1] Present address: The Rockefeller Foundation, Apartado Aereo 58-13, Bogota, Colombia, South America.

[2] Present address: Department of Poultry Husbandry, University of California, Davis, Calif.

to be required by the chick as well as sources of recognized but unidentified nutrients.

The low-fat basal diet contained approximately 25% protein and 320 calories of metabolizable energy per 100 g. The balance of protein to energy in this diet, 7.8 g. of protein per 100 cal., was maintained in the high-fat reference diet by substituting soybean oil for an equicaloric amount of glucose, based on the metabolizable energy values of 3.64 cal./g. for glucose (9) and 9.26 cal./g. for soybean oil (10). This method of substitution maintained a constant relationship between the sum of carbohydrate and fat calories, and all of the other dietary constituents, and accounts for the greater percentage levels of soybean oil meal and constant ingredients in diet II.

The soybean products which were used in these experiments were: a) whole soybeans; b) dehulled soybeans, representing the step in soybean processing just prior to flaking; c) dehulled unextracted soybean flakes compressed to a thickness of 0.007–0.010 in. (0.17–0.25 mm.) and identical with the flake made prior to solvent extraction in the production of soybean oil meal; d) dehulled extracted soybean flakes; and e) soybean hulls. Commercially-heated soybean oil meal (50% protein) was used for dehulled extracted soybean flakes. The other soybean products were obtained as raw (unheated) samples from a commercial processing plant. They were subjected to heat treatment under laboratory conditions as follows. The soybean products were coarsely ground in a Fitzpatrick mill through a screen with 6-mm. diameter mesh and brought to a moisture content of 20%. After remaining in a cooler (37–40°F.) over-night, they were autoclaved for exactly 30 min. in shallow pans at 107°C. (4 lbs. of pressure). Following this, they were dried in a forced air oven for 24 hrs., reground through a 2-mm. diameter mesh screen, and mixed. The method of heating unextracted soybean fractions was chosen to parallel as closely as possible the conditions encountered under commercial processing. Renner and Hill (8) showed that the conditions as employed in this experiment produce optimum results when applied to extracted soybean flakes or unextracted soybeans.

Composition data typical of the several lots of soybean products used are presented in Table II.

TABLE II
Typical Composition of Soybean Products

Soybean fraction	Moisture	Crude protein	Crude fat	Crude fiber	Ash
	%	%	%	%	%
Dehulled extracted flakes	11.0	52.0	0.9	2.2	5.5
Dehulled unextracted flakes	6.9	42.5	19.3	2.4	4.6
Dehulled soybeans	6.1	43.6	20.3	2.1	4.7
Whole soybeans	6.9	40.3	18.9	4.2	4.5
Soybean hulls	8.7	9.5	1.1	38.9	3.4

The purpose of the experiments was to evaluate the growth-promoting effect, metabolizable energy value, and absorbability of the fat in the various soybean products in comparison with soybean oil used as such in diet II. The composition of the experimental diets used is shown in Table III. Dehulled unextracted soybeans and dehulled unextracted soybean flakes were substituted in diet II to replace all of the soybean oil meal and soybean oil (diets III and IV). Nitrogen and fat levels were equalized in the respective diets on the basis of the composition of the particular lots of material used. Ground whole soybeans were substituted in diet II in a similar way (diet V), equalizing nitrogen and fat, but with the further assumption that soybean hulls which were calculated to make up approximately 5.1% of the soybean were without energy value (11). The substitution was made in such a way that the hull portion was incorporated at the expense of the whole diet rather than as a replacement for glucose. When soybean hulls were used as such (diets VI–IX), they were added at the expense of the whole diet. The data in Table III show the proportions computed on a percentage basis.

Several different lots of soybean products were used in the experiments to be described. The composition of diets used in each experiment was based on the composition of the materials prepared for it and differed in minor detail from the typical diets shown in Table III. Within each experiment the materials were derived as nearly as possible from a single lot of soybeans.

Experimental

All experiments were conducted in electrically-heated, thermostatically-controlled battery brooders with raised wire floors. Feed and water were given *ad libitum* for the experimental period. In Experiment 1 male crossbred (RIR x BPR) chicks were used while male White Plymouth Rock chicks were used in Experiments 2–9. The chicks were selected at random when started at one day of age in Experiments 1–3, 7, and 8, and duplicate lots of 10 chicks each were used per treatment. In Experiments 4–6 and 9, chicks were allowed free access to the basal low-fat diet until one week of age, then were divided into duplicate lots of 12 chicks each per treatment on the basis of one-week weights.

Chromium oxide (0.3%) was included in the diets for use in the determination of metabolizable energy and fat absorbability. Excreta were collected at 24-hr. intervals over a four-day period during the last week of the experiment. The method of analysis of diets and feces for determination of metabolizable energy was that described by Hill and Anderson (12) and Hill *et al.* (13). The diets were formulated on a dry-matter basis, and the metabolizable energy values of the unextracted soybean fractions were calculated as the difference between the metabolizable energy value of the respective diet and the metabolizable calories contributed by glucose and components of the premix, based on previously established values (14). The determination of absorbability of dietary fat was based on a modification of the method of Fowweather and Anderson (15) for the determination of fecal fat and fatty acids, as described by Renner and Hill (8). Corrections were made for the quantity of fat excreted by chicks receiving the basal diet. Dietary fat was determined by ether extraction.

Results and Discussion

Six experiments showing the comparative effects of extracted degummed soybean oil, dehulled unextracted soybean flakes, and ground unextracted soybeans on weight gain and efficiency of feed utilization of chicks are summarized in Table IV. The average weight gain of chicks receiving the soybean oil diet for all experiments was approximately 11% greater than that of chicks fed the low-fat basal diet, as shown at the bottom of the table. Unextracted soybean flakes were equally as effective as the combination of soybean oil meal and soybean oil in stimulating chick

TABLE III

Composition of Experimental Diets[a]

Ingredients	Diet III Flaked soybeans	Diet IV Dehulled soybeans	Diet V Ground soybeans	Diet VI Soybean oil plus hulls	Diet VII Flaked soybeans plus hulls	Diet VIII Dehulled soybeans plus hulls	Diet IX Basal plus hulls
	%	%	%	%	%	%	%
Glucose (Cerelose)	23.8	23.8	23.1	23.1	23.1	23.1	45.3
Soybean oil meal (50% protein)	......	......	......	47.1	......	......	39.9
Soybean oil, degummed	......	......	......	12.4	......	......	......
Constant ingredients	14.7	14.7	14.2	14.2	14.2	14.2	12.1
Heated ground unextracted soybeans	......	......	62.7	......	......	......	......
Heated dehulled unextracted soybean flakes	61.5	......	......	......	59.5	......	......
Heated ground dehulled unextracted soybeans	......	61.5	......	......	......	59.5	......
Heated soybean hulls	......	......	......	3.2	3.2	3.2	2.7

[a] All proportions are on a dry-matter basis.

growth and improving the efficiency of feed utilization. In contrast to results with dehulled unextracted soybean flakes, ground unextracted soybeans were less effective, as shown in Experiments 3–6. Feed conversion efficiency of chicks receiving the ground unextracted soybeans was also lower than with the other high-fat diets.

A possible explanation of the poor results obtained with diets containing ground soybeans as compared to soybean flakes and soybean oil is the lower energy yield from the soybeans. Renner and Hill (8) showed that the metabolizable energy value of soybeans was lower than expected because of the poor absorbability of the oil. Fat absorbability values obtained for soybean oil, dehulled unextracted soybean flakes, and ground unextracted soybeans used in Experiments 1–6, together with data from a seventh experiment, are summarized in Table V.

In agreement with previous work, the oil in ground unextracted soybeans was much less available than soybean oil fed as such. Flaking of the soybeans markedly improved the availability of the oil; its absorbability closely approached that of soybean oil fed as such. The reason for the marked improvement in availability of soybean oil because of the flaking process is not known. It seems probable however that the intense compression undergone by the soybeans during flaking caused a greater disruption of the cellular structure than did grinding, thus making the oil more accessible to digestive enzymes.

The reason for small differences between the absorbability values for extracted soybean oil and unextracted soybean flakes is not clear. It may be that flaking does not permit complete release of the oil in soybeans. Another possibility is that heating of the oil in the unextracted soybean flakes reduced its absorbability. However, in a separate experiment, degummed soybean oil, autoclaved under similar conditions, in combination with extracted soybean flakes, was absorbed as well by the chick as unheated oil and was well utilized for growth and efficiency. Data from this experiment are shown in Table VI. A third possible explanation for this difference is that the crude oil in unextracted soybean flakes is less well utilized than the more refined degummed soybean oil. However the degree of purification does not seem sufficient to account for the discrepancy.

The improvement in availability of the soybean oil brought about by flaking of soybeans produced a parallel improvement in the yield of metabolizable energy as is shown by the data in Tables VII and VIII. The composition of the soybeans and soybean flakes used in these experiments is also included in these tables. The average expected metabolizable energy for dehulled unextracted soybean flakes and unextracted soybeans was calculated from their respective yields of 50 and 44% protein soybean oil meal and soybean oil. For this calculation, values of 2.81 and 2.49 cal./g. were used, respectively, for 50% protein dehulled soybean oil meal and 44% protein soybean oil meal, and 9.19 cal./g. for crude soybean oil (8, 11). The observed metabolizable energy value for unex-

TABLE IV

Comparative Growth Promoting Value of Heated Degummed Soybean Oil, Heated Dehulled Unextracted Soybean Flakes, and Heated Ground Unextracted Soybeans

Supplement to low-fat basal diet	Average weight gain[a]	Feed per unit gain
Experiment 1	*gm.*	
None	370	1.89
Soybean oil	405	1.60
Unextracted soybean flakes	416	1.60
Experiment 2		
None	480	1.67
Soybean oil	524	1.44
Unextracted soybean flakes	555	1.40
Experiment 3		
None	550	1.58
Soybean oil	598	1.36
Unextracted soybean flakes	602	1.36
Ground unextracted soybeans	573	1.57
Experiment 4		
None	488	1.84
Soybean oil	548	1.45
Unextracted soybean flakes No. 1	534	1.42
Unextracted soybean flakes No. 2	527	1.47
Ground unextracted soybeans	520	1.69
Experiment 5		
None	482	1.82
Soybean oil	565	1.42
Unextracted soybean flakes	569	1.44
Ground unextracted soybeans	545	1.71
Experiment 6		
None	508	1.59
Soybean oil	570	1.31
Unextracted soybean flakes	566	1.37
Ground unextracted soybeans	538	1.48
Mean relative data from all experiments	%	%
Basal (low-fat) diets	100	100
Basal + soybean oil	111	83
Basal + unextracted soybean flakes	112	83
Basal + ground unextracted soybeans	107	94

[a] Experiments 1–3 are gain from 0–4 weeks of age; experiments 4–6, 1–4 weeks of age.

TABLE V

Absorbability of Extracted Soybean Oil and Oil in Unextracted Soybeans and Soybean Flakes[a]

Experiment	Degummed oil	Heated dehulled unextracted flakes	Heated ground unextracted beans
	%	%	%
1	96	92	....
2	95	88	....
3	....	92	70
4	96	90 & 92	73
5	95	92	60
6	95	91	78
7	91	92	63
Average	95	91	69

[a] Data represent averages obtained from duplicate lots of chicks.

TABLE VI
Effect of Heating on the Utilization of Soybean Oil [a]

Supplement to low-fat basal diet	Weight gain 4 weeks	Feed/gain	Fat absorbability
	gm.		%
None	550	1.58	....
Unheated soybean oil (14.4%)	598	1.36	95
Heated soybean oil (14.4%)	597	1.33	94

[a] Data represent averages obtained from duplicate lots of 10 White Plymouth Rock male chicks.

tracted ground soybeans was 14% less than that computed in this way, confirming the previously reported work on soybeans from this laboratory, which is also listed in Table VI. Flaking of the soybeans brought their metabolizable energy value close to the expected value; the average difference between the expected and observed values in this case was only 5%. The observed discrepancies in metabolizable energy values were accounted for mostly by the differences in fat absorbability. This is shown in the last column of Tables VII and VIII where the metabolizable energy value of the ground unextracted soybeans and dehulled unextracted soybean flakes are adjusted to the basis of 95% absorbability of the oil.

TABLE VII
Protein and Fat Composition and Metabolizable Energy Value of Heated Ground Unextracted Soybeans [a]

Experiment	Composition		Metabolizable energy			
	Protein	Fat	Expected	Observed [b]		Adj. to fat absorb. of 95%
	%	%	Cal./gm.	Cal./gm.	Cal./lb.	Cal./gm.
3	42.8	19.7	3.71	3.21	1457	3.55
4	42.2	20.0	3.73	3.32	1507	3.65
5	42.1	19.4	3.69	3.04	1380	3.51
6	42.2	22.6	3.91	3.57	1621	3.88
7	42.1	20.7	3.78	2.96	1344	3.41
Renner & Hill (1960)	43.5	20.3	3.80	3.38	1535	3.62
Average of 6 lots	42.5	20.5	3.77	3.25	1474	3.60

[a] All values expressed on a dry-matter basis.
[b] Data represent averages of values obtained from duplicate lots of chicks.

In addition to being flaked, the unextracted soybean flakes used in this work had also been dehulled. The results of two experiments to determine the influence of soybean hulls are presented in Table IX. Soybean hulls were added to the diet at a level equal to that provided by ground soybeans (diet V).

In Experiment 8 significant growth stimulation was produced by soybean oil, soybean flakes, and dehulled soybeans. Ground soybeans were less effective. The addition of hulls did not reduce the effectiveness of soybean oil or soybean flakes; however the return of hulls to the dehulled soybeans resulted in performance essentially equal to the ground soybeans. The data suggested that dehulled soybeans were a marginal source of the growth-stimulating property as compared to soybean oil or flakes. However analysis of variance (16) and application of Duncan's multiple range test (17) to the growth data indicated that the only groups significantly different from the soybean oil control diet ($P<0.05$) were the basal diet and basal diet plus hulls.

Experiment 9 was conducted with chicks selected at one week of age. In this experiment no sigificant effect of hulls was observed on growth rate, and chicks receiving diets containing ground soybeans grew nearly as rapidly as those receiving soybean flakes. Although growth rate appeared unaffected, the presence of soybean hulls, in general, resulted in slightly poorer efficiency of feed utilization, as might be expected from their low metabolizable energy content. Therefore, while the growth improvement observed with dehulled unextracted soybean flakes as compared to ground unextracted soybeans may be attributed to the flaking process, part of the increase in efficiency of feed utilization was the result of the prior removal of soybean hulls. The data in Table IX also show clearly that dehulling or the presence of hulls in the diet had no effect on fat absorbability.

TABLE VIII
Protein and Fat Composition and Metabolizable Energy Value of Heated Dehulled Unextracted Soybean Flakes [a]

Experiment	Composition		Metabolizable energy			
	Protein	Fat	Expected	Observed [b]		Adj. to fat absorb. of 95%
	%	%	Cal./gm.	Cal./gm.	Cal./lb.	Cal./gm.
1	45.2	20.9	4.08	3.86	1752	3.95
2	44.3	20.3	4.05	3.60	1634	3.73
3	44.6	21.4	4.12	3.94	1789	4.04
4	45.3	22.2	4.17	4.11	1866	4.24
	44.4	22.3	4.16	4.10	1861	4.21
5	44.4	22.8	4.21	4.10	1861	4.21
6	43.9	23.4	4.24	4.03	1830	4.16
7	44.4	20.8	4.07	3.71	1684	3.81
Average of 8 lots	44.6	21.8	4.13	3.93	1785	4.04

[a] All values expressed on a dry-matter basis.
[b] Data represent averages of values obtained from duplicate lots of chicks.

The experiments described show that the greatest benefit to be derived from the flaking of soybeans is a marked improvement in the efficiency of feed utilization because of the improved availability of the energy in soybeans after flaking. This is mainly a result of the greater absorbability of the oil in unextracted soybean flakes. However it also appears that some benefit in terms of growth rate is also obtained by the flaking of soybeans. In all cases where chicks were fed diets containing ground unextracted soybeans, growth rate was somewhat less than with diets containing flaked soybeans or the combination of soybean oil meal and soybean oil. While these differences have not been significantly different in any one experiment, they have occurred consistently. Whether this results from the lower absorbability of the oil in ground unextracted soybeans, compared to the flaked soybeans or the free soybean oil fed as such, is not clear. It is possible that the presence of the soybean hull is partially responsible for this difference in growth-promoting ability in view of the inconsistent results in these experiments with hulls.

The energy level and availability of oil in diets containing ground soybeans is considerably less, compared to that of diets containing equal quantities of total oil supplied either in the free form or as flaked soybeans. This would suggest that the poorer growth stimulation obtained with diets containing ground soybeans is related to the lower dietary energy level or to the poorer absorbability of the oil. The first possibility, lower dietary energy level, is probably not the answer since Rand *et al.* (1) and Carew (18) have shown that growth stimulation with dietary vegetable oils is not directly related to changes in dietary energy concentration. More likely, the differences in growth rate are due to a property of soybean oil,

TABLE IX

Effect of Soybean Hulls on Growth, Feed Efficiency, and Fat Absorbability[a]

Diet number and treatment[c]	Average weight 4 weeks		Feed/gain[b]		Fat absorbability	
	Exp.8	Exp.9	Exp.8	Exp.9	Exp.8	Exp.9
	gm.	gm.			%	%
I. Basal	591	598	1.58	1.82	....	....
II. Soybean oil	639	683	1.36	1.42	....	94.8
III. Soybean flakes	643	685	1.36	1.44	92.1	92.3
IV. Ground dehulled soybeans	643	667	1.47	1.58	72.9	67.3
V. Ground unextracted soybeans	614	658	1.57	1.71	70.4	60.0
VI. Soybean oil + hulls	662	663	1.34	1.49	....	....
VII. Soybean flakes + hulls	640	649	1.38	1.47	....	....
VIII. Ground dehulled soybeans + hulls	612	663	1.49	1.60	74.0	65.0
IX. Basal + hulls	569	627	1.62	1.75	....	....

[a] Data represent averages of duplicate lots of chicks.
[b] Experimental periods: Experiment 8, 0–4 weeks; Experiment 9, 1–4 weeks.
[c] All soybean products were heated.

unrelated to its energy contribution, or to a factor present therein, the availability of which is directly proportional to the quantity of oil in the diet capable of being absorbed by the chick.

In studies employing the basal diet described in these experiments it was found that a dietary level of approximately 9% soybean oil with an absorbability of 95% is required to promote maximum growth stimulation in male chicks to four weeks of age. With an average absorbability of 69%, ground unextracted soybeans supply the equivalent of about 8.9% absorbable oil to the diet. Therefore, with this level of absorbable oil in the diet, it is possible that diets containing ground unextracted soybeans may be marginal in the growth-promoting property of soybean oil. The possibility cannot be excluded however that the fraction of oil in ground unextracted soybeans, which is unavailable to chicks, contains a higher concentration of the growth-promoting property compared with the oil which is readily absorbed.

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Heated Fats. I. Studies of the Effects of Heating on the Chemical Nature of Cottonseed Oil[1]

DAVID FIRESTONE, WILLIAM HORWITZ, LEO FRIEDMAN, and GLEN M. SHUE,
Bureau of Biological and Physical Sciences, Food and Drug Administration, Department of Health, Education, and Welfare, Washington, District of Columbia

When cottonseed oil was heated at 225°C. in the presence of air for long periods of time, nonurea adduct-forming monomers and dimers were formed which were toxic to rats. Analyses showed that the toxic fractions contained moderate amounts of carbonyl and hydroxyl and that they contained unsaturation difficult to remove by hydrogenation. Cyclic structures appeared to be present in the dimer fraction. The production of nonurea adducting monomers and dimers is associated with polymerization and other reactions of linoleic acid.

IN STUDIES from several laboratories evidence has been presented that oxidized and polymerized fats contain substances which are toxic to experimental animals. Crampton and coworkers (1–6) found that vegetable oils polymerized at 275°C. in an inert atmosphere caused growth depression in rats. The nonurea adduct-forming monomers from linseed oil were lethal to rats at 10% levels in the diet. It was suggested that these toxic monomers contain a cyclic structure. Other studies (7–12) indicate that cyclic monomers are produced from polyunsaturated acids by way of Diels-Alder reactions.

Perkins and Kummerow (13) observed that thermal oxidation of corn oil at 200°C. produced polymeric substances containing high percentages of hydroxyl and carbonyl groups. The unsaturation present in the polymers was difficult to remove by hydrogenation. No monomers or polymers with cyclic structures were found in the thermally oxidized oil, and it was suggested that the free radical mechanism proposed by Sunderland (14), which results in polymerization through a single carbon-carbon bond, could account for the polymers derived from the thermally oxidized corn oil. A group of weanling rats were fed the nondistillable residue (dimers and high polymers) of the nonurea-forming fatty acids from corn oil thermally oxidized at 200°C. for 48 hrs.; all died within 7 days (15). The molecular distillate obtained from the non-

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