TABLE III

Reproduction and Lactation of Rats on Margarine Oil Diets

Generation	Reproduction			Lactation	
	Females, pregnant /mated	Mean litter size	Litters, mean weight (3 days) g.	Weaned /born, %	Mean weaning weight, g.
Regular Margarine Oil Diet (Margarine oil contained 18,500 U.S.P. units natural vitamin A per pound)					
P	10.1	14/15	....	90	35.3
F_1	9.8	13/15	9.0	92	36.3
F_2	7.3	11/13	8.3	89	41.8
High Vitamin A Margarine Oil Diet (Margarine oil contained 1,850,000 U.S.P. units synthetic vitamin A per pound)					
P	9.5	12/15	....	96	35.1
F_1	7.3	15/15	8.7	100	40.3
F_2	8.3	13/15	8.2	88	40.4

The ratios of mean litter size at weaning to mean litter size at birth were very similar, and the mean weaning weights of the young were not significantly different between groups fed either the regular margarine oil or the high vitamin A margarine oil diets.

General Appearance. The animals on both margarine oil-containing diets appear to be normal in every respect. Compared with stock colony animals of the same age and sex, they are identical with respect to growth, fur condition, "feel" and general appearance.

Pathological Examination. Ten rats identified only by number were submitted to Karl E. Mason, University of Rochester School of Medicine and Dentistry, for gross and histological examination. The animals were F_1 generation males, 33 weeks of age. Five were representative of the regular margarine oil group (511, 512, 524, 530, and 536) and five of the high vitamin A margarine oil group (520, 526, 528, 538, and 539). Dr. Mason's detailed report may be summarized as follows. Gross observations of all 10 rats at necropsy showed them to be in good physical condition with no unusual changes. One rat (512) showed some adhesions around the pericardium, and 7 rats had slightly enlarged cecums. Histological examination of skeletal muscle, heart, liver, spleen, large and small intestine, thymus, and adrenals showed them to be normal for adult rats. Some tissues showed abnormalities, but it should be emphasized that such deviations from normal occur with variable frequency in animals of the age represented by those of this group. Some local degeneration of acinar tissue of the pancreas occurred in two animals (512 and 520). Advanced degeneration of the testes was found in one rat (520) and partial degeneration in another (524). Two animals (538 and 539) showed hydronephrosis of the right kidney. Moderate hyperplasia of lymphoid tissue as commonly occurs in older animals was generally present. Peribronchial lymphocytic infiltration, combined with some vascular congestion, was common in most animals of this series. In general, the pathological findings indicated no marked differences in the tissues and organs of animals maintained on the two diets.

Discussion

Results of these nutritional studies on albino rats show that the feeding of margarine oil fortified to 100 times the usual amount of vitamin A with synthetic vitamin A palmitate, compared with regular margarine oil, results in comparable response for growth, reproduction, and lactation. The two groups of rats in these experiments consumed, respectively, about 30 and 3,000 units of vitamin A daily (assuming 10 gms. of diet eaten per day). On the basis of body weight the animals given the highly fortified margarine at the start of the experiment received about 30,000 units/kg. (50 gms. body weight; food intake about 5 gms.), which gradually decreased to about 11,000 units/kg. (400 gms. body weight; food consumption about 15 gms.) at the end of the study. At these levels of synthetic vitamin A no deleterious effects were observed. This is in accord with previous observations on hypervitaminosis A in the rat obtained with both natural and synthetic vitamin A concentrates (1, 4).

Summary

The growth, reproduction, and lactation of three generations of albino rats fed diets containing 7.5% of margarine oil fortified with synthetic vitamin A palmitate to contain 1,850,000 units of vitamin A per pound of fat (1,500,000 units per pound of margarine) was investigated. This level of supplementation gave normal responses comparable to those shown by animals fed regular margarine oil (18,500 units of natural vitamin A per pound of fat or 15,000 units per pound of margarine).

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Effect of Over-Cooking of Cottonseed Meats on Quality of Meal

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THE cooking of cottonseed meats has received much attention during the past years in an attempt to decrease oil mill maintenance costs, increase mill capacity, and improve oil quality. In pursuing these goals, a cooking process was defined in July, 1950 (1) wherein the necessity of a minimum of 12% moisture during the cooking stage was emphasized. This cooking process consists of maintaining the meats at 185 to 200°F. at the minimum 12% moisture content for a period of time of 15 to 17 minutes. The cooked meats are then dried for expression of oil. Earlier reports (1, 2) showed that this cooking process made it possible to produce a low refining loss oil from cottonseed when the seed were milled by the Exsolex process.

More recent information shows that this cooking process makes possible an improvement in oil quality and an increase in seed capacity when used with an Expeller for single pressing. For example, the Lubbock Cotton Oil Company at Lubbock, Texas, has operated an expeller mill and a hydraulic mill for the last two seasons within the same mill building. During the last season and a half when a cooking procedure, as defined above, was utilized the expeller oil had refining characteristics identical to the hydraulic oil. The four expellers in the line were operated at an average capacity of approximately 25 tons of cottonseed per day. The oil content of the expeller cake averaged approximately 3.6%.

Very recently the Lubbock Cotton Oil Company increased the r.p.m. of the shafts of one of their expellers in order that the meats from approximately 50 tons of cottonseed could be single-pressed in this expeller. Over a period of two days the expeller processed the meats from an average of 46.4 tons of cottonseed per day. The cake from this operation contained 43.3% protein and 4.3% oil. These data indicated that a proper cooking procedure not only enables the production of a hydraulic quality of cottonseed oil when using expellers for single pressing but also enables the capacity of an expeller to be increased appreciably.

During the 1950-51 milling season studies were conducted to ascertain the effect of the above cooking procedure on the quality of cottonseed meal. In line with present-day information free gossypol and soluble protein contents of the meal were used as criteria of meal quality. Samples of meal from a hydraulic mill, an expeller mill, and an Exsolex mill, all of which were employing the cooking procedure described above, were analyzed. Data from these samples are summarized in Table I.

TABLE I

Cottonseed Meal Analysis

	Exsolex meal	Expeller meal	Hydraulic meal
H_2O, %	10.0	10.0	10.0
Oil, %	.40	3.48	5.29
Soluble protein, %	38.5	11.3	30.7
Free gossypol, %	0.029	0.019	0.068

The data in Table I indicate that the hydraulic meal contained approximately .07% gossypol. Approximately 30% of the protein in the hydraulic meal was soluble in 0.5 molar NaCl. The expeller meal contained a much lower content of gossypol but also a much lower content of soluble protein. The Exsolex meal however contained not only a reasonably low free gossypol content but also the highest soluble protein content.

In order to ascertain a means of reducing the free gossypol in the Exsolex meal a series of mill runs was set up wherein the cooking time was extended to the extreme of 50 minutes. The moisture of the meats was maintained at 12.3%, and the temperature was held at 185°F. during the cooking process. The data plotted in Figure I show the relationship of temperature, free gossypol content, and soluble protein content to the time of operation from the point of initiating the cooking process to that of cooling the meal for grinding.

It is observed from Figure 1 that the temperature of the cottonseed meats was raised to 185°F. during the cooking stage and then to a final temperature of 220°F. during the drying stage. Although the exact temperature of the cake from the expeller could not be accurately determined, a temperature of 250°F. is indicated as the temperature of the cake issuing from the prepress expellers. The cake was then gran-

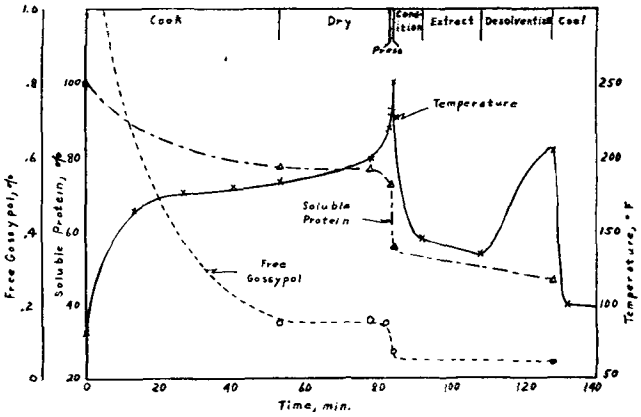

FIG. 1. Relation of temperature and time to free gossypol destruction and soluble protein denaturization in the Exsolex process.

ulated and cooled to 145°F. prior to flaking. The solvent extraction phase was conducted at 135°F. The desolventizing of the meal was conducted so that the final temperature of the meal was 200°F. The meal was then cooled to 100°F. for grinding.

Figure 1 shows that the free gossypol content of the rolled meats was reduced from 1.22% to 0.147% during the cooking process. The drying of the meal brought about a negligible decrease in gossypol content. By passing the cooked and dried meal through the prepress expeller, a slight decrease in free gossypol occurred. The solvent extraction and desolventizing steps brought about a further slight decrease in gossypol content to a final value of 0.044%. All free gossypol content data are calculated to an oil and moisture free basis.

The protein in the original meats that was soluble in 0.5 molar NaCl solution amounted to 81.7%. For purposes of graphing this value was designated as 100% solubility. The protein solubility data therefore represent the percentage of the original soluble protein that remained soluble through the various steps of the process.

The soluble protein was decreased from a value of 100% to approximately 75% before entering the prepress expeller. An abrupt drop in soluble protein occurred as the meats were processed in the expeller, thus furnishing a prepressed cake which contained 55% of the original soluble protein. Again only a slight decrease of soluble protein occurred during the extraction and desolventizing steps so that the final value was 44%.

Since the extension of cooking time did not effect a reduction of gossypol content in the finished meal, some runs were made wherein the moisture content of the meats during the cooking process was reduced.

For these runs the cooking time was maintained at 50 minutes, and the cooking temperature was main-

tained at 185°F. The moisture content of the meats was adjusted in the different runs from 12.3% to 11.7% to 11.0%. The data in Table II show the effect of this moisture difference on the free gossypol and soluble protein contents of the cooked meats.

It is concluded therefore that an extension of the cooking time, in itself, has very little effect upon the reduction of the free gossypol in a finished meal or upon the soluble protein content of a finished meal. Since the data do indicate however that the moisture content of the meats during the cooking stage is critical, this factor is being studied further in order to arrive at the optimum value during the cooking process.

TABLE II

Effect of Moisture During the Cooking of Cottonseed Meats on Free Gossypol Destruction

Moisture contents, %	12.3	11.7	11.0
Free gossypol content of cooked meats, %	0.09	0.12	0.15
Soluble protein value of cooked meats, %	73.5	73.8	80.9
Free gossypol content of finished meal, %	0.04	.....	0.06

Acknowledgment

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Thermal Properties of Fats and Oils. VIII. Specific Heats, Heats of Fusion, and Entropy of Alpha and Beta Tung Oils[1]

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DATA found in the literature for the thermal properties of tung oil include the specific heats of China wood oil over a temperature range of 70° to 155°C. (6) and the specific heats of a tung oil of unknown origin over a temperature range of 0° to 200°C. (3). No other thermal constants could be found. The specific heats of the alpha or liquid tung oil reported in this communication are believed to be the first available for the oil expressed from the nuts of *Aleurites fordii.*

Data are also reported for the specific heats in both solid and liquid states, heats of fusion, entropies at 298.16°K., and heat content and the percentage of liquid glycerides present at any temperature over the complete range of melting for both the alpha (liquid) and beta (solid) forms of tung oil of known origin.

Experimental

Oils. The liquid or alpha tung oil used in this investigation was screw-pressed from the kernels of fruit from the 1949 crop. A portion of this oil was isomerized in the presence of light by the addition of one part of a saturated solution of potassium iodide to 1,000 parts of oil. The mixture was stirred for 15 minutes, filtered, and stored for 5 days, all operations under nitrogen. The isomerized oil was melted before use, put into the calorimeter under nitrogen, and the apparatus sealed.

The alpha tung oil used in the tests contained the equivalent of 82.0% of α-eleostearic acid and 0.0% of β-eleostearic acid when examined spectrophotometrically by the method of O'Connor *et al.* (7). The beta oil contained 10.8% of α-eleostearic acid and 61.4% of β-eleostearic acid. Examination for total eleostearic acid (7) showed the alpha oil contained 80.6% and the beta oil contained 74.6%.

Comparison of the spectrophotometric analyses of the alpha and beta oils before and after calorimetric examination indicated that no change had occurred in the respective contents of α- and β-eleostearic acids. Upon removal from the calorimeter after an interval of about three months, the isomerized sample contained approximately 0.3% by weight of a gel-like material, which was probably oxidized oil.

Apparatus and Method. The calorimetric apparatus and method used in the present investigation have been described in an earlier report (2). Briefly, a weighed sample of oil, weight corrected to vacuum, was sealed in a copper calorimeter, which was enclosed in a semi-adiabatic system, and the calorimeter and sample were brought to the proper temperature level. Liquid nitrogen was used to obtain temperatures below 193°K.(—80°C.), and solid carbon dioxide was used for temperatures from 193° to 273.16°K.(—80° to 0°C.). Melting ice or a constant temperature bath was used for higher temperatures. To obtain the calorimetric data a measured amount of heat was put into the sample by means of an electric current flowing through a resistance, and the resulting changes in temperature were measured potentiometrically. The accuracy of the results obtained is believed to be within 1%.

The thermochemical calorie, which is equal to 4.1840 absolute joules, was used in all calculations.

Prior to the thermal investigation it was found that beta tung oil melted at three different temperatures; each melting point is dependent upon the rate of cooling of the liquid oil. Slow cooling of the melt in capillary tubes produced a solid with a melting point of 52.8°C. Such cooling was attended by considerable

[1] A report of a study made under the Research and Marketing Act of 1946.

[2] One of the laboratories of the Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, U. S. Department of Agriculture.