Bulletin 860

Studies on Feed Spoilage...

Heating in Feed Ingredients and Mixtures Containing Molasses and Added Fat

May 1957

TEXAS AGRICULTURAL EXPERIMENT STATION
R. D. LEWIS, DIRECTOR, COLLEGE STATION, TEXAS

DIGEST

Studies described in this bulletin are:

(1) The critical moisture levels of various protein concentrates.

(2) The critical moisture level of 30 individual feed ingredients including grains and grain byproducts, protein concentrates, dehydrated alfalfa meals and bone meal.

(3) Heating in mixtures containing cornmeal and different kinds of molasses.

(4) Heating in mixtures containing alfalfa leaf meal and cane molasses.

(5) Heating in mixtures containing corn meal and fat and in those containing soybean meal and fat.

Some variation occurred in the critical moisture level of protein concentrates prepared at different times by the same process and in those prepared by different processes. The amount of protein in the concentrates did not appear to affect the critical moisture level. In general, the exact critical moisture level depended on the specific ingredient and the individual preparation.

Heating in mixtures containing molasses depended on the moisture content of both the ingredient and the molasses. If the ingredient had a low moisture content, the addition of molasses high in moisture did not cause heating. But, if the molasses was low in moisture, the mixture heated when the ingredient was high in moisture. A feed mixed with molasses low in moisture did not heat so readily as one mixed with molasses high in moisture.

In general, the addition of fat to a feed ingredient did not cause spontaneous heating in the mixture. However, a mixture containing a large amount of fat heated at a lower total moisture level than one containing a small amount of fat. This difference was due to the high moisture content of the non-fat portion of the mixture when fat was present. All of the moisture is in the non-fat portion of the mixture. Consequently, the non-fat portion of the mixture high in fat is relatively higher in moisture than one with the same total moisture that is low in fat.

ACKNOWLEDGMENTS

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Acknowledgment is made to K. N. Wright, sales manager, A. E. Staley Manufacturing Company, for the 40 percent soybean oil meal and the 50 percent dehulled soybean meal; to Theodore M. Miller, Wallace Menhaden Products, Inc., for menhaden fish meal and fish scraps; and to Buford Barrows, Hales and Hunter Company for flaked barley, flaked wheat and crimped oats.

This manuscript was adapted in part from a dissertation submitted to the Graduate School of the Agricultural and Mechanical College of Texas by John V. Halick in partial fulfillment of the requirement for the Degree of Doctor of Philosophy.

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Heating in Feed Ingredients and Mixtures Containing Molasses and Added Fat

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RESULTS OF EARLIER STUDIES on the critical moisture level of feed ingredients have been reported by Halick and Richardson in Texas Station Bulletin 768, "Influence of Moisture on Heating in Feeds." The influence of the moisture content of corn meal and of molasses on heating in various mixtures of corn meal and molasses were described in the same report. Additional studies have been carried out on this problem and the results are described herein.

These studies include: (1) the critical moisture level of alfalfa meals, distillers grains and various protein concentrates; (2) heating in mixtures containing corn meal and different kinds of molasses; (3) heating in mixtures containing alfalfa leaf meal and cane molasses; and (4) heating in mixtures containing fat.

RESULTS

The apparatus used to study heating was the same as that described in Bulletin 768. In general, the following procedure was used to determine the safe moisture level of an ingredient. Several kilos of the ingredient were dried in a circulating air oven at a temperature of approximately 65°C. The amount of water required to give the desired moisture content was calculated for each 2 kilograms of material. Four lots of 2 kilos of an ingredient, each with a different moisture content, were used per trial. An attempt was made to add water to different lots so that the moisture content between two lots differed by 0.5 to 1.0 percent. An attempt also was made to adjust the moisture level in one lot in each trial so that it did not heat, and in another lot so that it heated. Each lot of 2 kilos was placed in a 4-liter Dewar flask. The flask and contents were then maintained in an insulated cabinet at a temperature of 90° F, and a relative humidity of 70 percent. A thermocouple in each flash was connected to a multiple point Electronik temperature indicator. The temperature in each flask was recorded daily.

The procedure used to determine the critical moisture level of an ingredient is illustrated with soybean oil meal that contained 44 percent protein. Three separate tests were run to establish the critical moisture level of this ingredient. The first trial was composed of five 2-kilo lots of soybean meal with 11.4, 14.1, 15.1, 15.9, and 16.9 percent moisture. The second trial was composed of four 2-kilo lots with 12.8, 13.9, 14.5 and 15.0 percent moisture. The third trial was composed of four 2-kilo lots with 11.2, 13.9, 15.1 and 16.4, percent moisture. The moisture levels at which the soybean meal did and did not heat in the different trials are summarized in Table I.

In the first trial, the soybean meal with 15.1 percent moisture heated in 26 days. It did not heat with 14.1 percent moisture. In the second trial, the soybean meal with 15.0 percent moisture heated in 26 days. It did not heat with 14.5 percent moisture. In the third trial, the soybean meal with 15.1 percent moisture heated in 35 days, but did not heat with 13.9 percent moisture. These data show that the critical moisture level of this particular sample of soybean meal was between 14.5 and 15.0 percent.

Critical Moisture Level of Protein Concentrations

Safe and unsafe moisture levels of protein concentrates were determined in lots which had been prepared by different processes or had been obtained from different sources. These data are summarized in Table 2. The data show that there was some variation in the moisture content at which concentrates heated, and this variation occurred whether the concentrates were prepared by the same process at different times or by a different process. The following examples will illustrate these points. A cottonseed meal prepared by the expeller process in 1953 heated with 12.1 percent moisture. Another lot prepared by the same process in 1955 with 12.6 percent moisture did not heat. Cottonseed meal prepared in 1953 may be used also to illustrate variations in heating due to differences in the process used for

TABLE 1. DETERMINATION OF A SAFE MOISTURE LEVEL OF SOYBEAN MEAL

Trial no.	Did not heat	Heated	Started to heat
	% moisture	% moisture	Days
1	14.1	15.1	26
2	14.5	15.0	25
3	13.9	15.1	35

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its manufacture. Cottonseed meal prepared by screw press and expeller processes with 12.0 and 12.1 percent moisture, respectively, heated. The meal prepared by the prepress solvent process with 12.8 percent moisture was safe from heating.

One lot of a dehulled solvent extracted soybean meal which contained 50.0 percent protein, and 15.4 percent moisture did not heat in 1953. Similar meals prepared at different times in 1955 and containing 15.4 and 15.3 percent moisture respectively, did heat. A solvent extracted soybean oil meal containing 44 percent protein and approximately 1.0 percent less moisture than the dehulled soybean meal heated as rapidly as the dehulled meal.

These data show that the exact moisture content at which an ingredient will heat depends on the specific material more than any other factor. The amount of protein present and the method of preparation do not appear to be important factors. Under practical conditions, a moisture content of 1 to 1.5 percent less than that for any single lot of a feed ingredient would be relatively sa from heating.

TABLE 2. MOISTURE CONTENT OF PROTEIN CONCENTRATES WHICH HEATED AND WHICH DID NOT HEAT

Protein concentrate	Protein	No. of trials	Year	Did not heat	Heated	Started heating
	%			% moisture	% moisture	Days
Corn gluten meal		3	1954	11.0	11.5	34
Cottonseed meal						
Screw press	41	4	1953	11.4	12.0	27
Screw press	41	1	1955	11.5	[1]	[1]
Expeller	42	3	1953	[1]	12.1	28
Expeller	40	2	1955	12.6	13.0	26
Prepress solvent	41	3	1953	12.8	13.4	31
Prepress solvent	40	1	1955	12.5	[1]	[1]
Fish meal						
Unknown	63	3	1954	11.5	11.6	38
Unknown		3	1955	11.4	[1]	[1]
Menhaden	61	3	1954	[1]	10.7	30
Menhaden	62	3	1955	9.9	10.3	23
Fish scrap						
Menhaden	60	2	1954	10.2	10.9	17
Menhaden	60	1	1955	9.6	10.1	24
Linseed meal		2	1954	10.6	11.3	36
Meat and bone scraps	50	3	1954	10.0	11.0	23
Sorghum						
Gluten meal		3	1953	11.0	11.2	26
Gluten meal residue		4	1954	16.3	17.3	37
Soybean oil meal						
Unknown	44	2	1953	13.1	13.3	28
Soybean oil meal						
Solvent extracted[2]	50	3	1953	15.4	15.8	37
Solvent extracted[2]	50	3	1955	14.2	15.4	19
Solvent extracted[2]	50	4	1955	13.7	15.3	33
Soybean oil meal						
Solvent extracted	44	3	1953	14.5	14.9	35
Solvent extracted	44	2	1955	14.4	14.7	13
Solvent extracted	44	2	1955	13.8	14.3	28

[1]No observations.

[2]Dehulled.

The critical moisture level of all feed i gredients that has been determined in this labor tory are given in Table 3.

Heating in Mixtures Containing Molasses

Feeds containing molasses heat more frequen ly than those containing any other ingredient Studies were carried out to determine the in fluence of the source and moisture content o the molasses on heating in mixtures containing corn meal and molasses. The corn meal used in these tests contained 12.7 percent moisture and did not heat in 42 days, but its moisture content was very close to the critical level.

TABLE 3. CRITICAL MOISTURE LEVELS OF FEED INGREDIENTS

Ingredient	Critical moisture
	%
Barley, flaked	14.2
Bone meal	
1953	9.5
1952	8.7[1]
Corn	
Whole	14.7[1]
Ground	13.0[1]
Corn gluten meal	11.0
Cottonseed meal	
Expeller	11.5
Screw press	11.5
Prepress solvent	12.8
Dehydrated alfalfa	
Stem meal	15.1
Leaf meal	14.9
Distillers	
Dried grains and corn solubles	15.9
Dried grains (sorghum)	17.0
Fish meal	
Unknown	11.5
Menhaden	9.9
Fish scrap	9.6
Linseed meal	10.6
Meat and bone scraps	10.0
Sorghum gluten meal	11.0
Sorghum grain	
Whole	12.7[1]
Ground	13.0[1]
Oats	
Crimped	13.1[1]
Ground	12.3[1]
Whole	14.5[1]
Rundermeel	9.6
Soybean meal	
44% protein	13.1
44% protein	13.8
50% protein	15.4
Wheat	
Whole	14.3[1]
Flaked	13.7
Ground	12.0[1]
Bran	13.0[1]
Shorts	12.7[1]

[1]Previously reported in Bulletin 768.

The corn meal was mixed with 10 and 15 percent of one lot of cane molasses that contained 22 percent moisture, and with another lot that contained 27 percent moisture. The same corn meal was mixed with 10 and 15 percent corn molasses (Hydrol) that contained 23 percent moisture and with the same amount of sorghum molasses that contained 20 percent moisture. These data are summarized in Table 4.

All the mixtures containing molasses heated, with the exception of the one containing 15 percent corn molasses. Mixtures with cane molasses containing 22 percent moisture started to heat in 23 days, while those containing molasses with 27 percent moisture started to heat in 7 to 9 days. Mixtures containing corn and sorghum molasses started to heat at about the same time as those containing cane molasses with 22 percent moisture.

Another test was carried out to determine the influence of the moisture content of molasses on heating in mixtures containing alfalfa leaf meal and cane molasses. When the alfalfa leaf meal contained 9.1 percent moisture, none of the mixtures containing 10, 15, 20 or 40 percent of molasses heated, whether the molasses contained 20 or 28 percent moisture. The alfalfa leaf meal containing 14.3 percent moisture was mixed with 10, 15, 20 and 40 percent molasses. When molasses containing 20 or 28 percent moisture was mixed with dehydrated alfalfa leaf meal that contained 9.1 percent moisture, none of the mixture heated. Even though the moisture level of the mixture which contained 40 percent molasses with 28 percent moisture was above the critical level of the dehydrated alfalfa leaf meal, it did not heat. It is possible that the osmotic concentration of the mixture containing 40 percent molasses was too high for the molds to grow. The results obtained when molasses was added to the dehydrated alfalfa leaf meal that contained 14.3 percent moisture are shown in Table 5. When the moisture content of alfalfa leaf meal was 14.3 percent, none of the mixtures with molasses that contained 20 percent moisture heated, but when mixed with molasses that contained 28 percent moisture, those with 10, 15 and 20 percent molasses heated. Again the mixture containing 40 percent of molasses did not heat probably because the high level of molasses may increase the osmotic concentration of the mixture. If the moisture content of the ingredient is decidedly below the critical level, the addition of relatively large amounts of molasses with a high moisture level will not cause the mixture to heat.

These data are in agreement with those reported in Bulletin 768, that a feed mixed with a molasses low in moisture will not heat as readily as one mixed with a molasses high in moisture, but the use of a molasses low in moisture alone will not insure the absence of heating. The moisture content of the other ingredients is just as critical as that of the molasses, and the moisture

TABLE 4. HEATING IN MIXTURES OF CORN MEAL[1] AND MOLASSES FROM DIFFERENT SOURCES

Molasses		Moisture		Started heating
Source	Amount added	Molasses	Mixture	
	%	%	%	Days
Cane	10	22	13.8	26
	15	22	14.2	23
	10	27	14.1	9
	15	27	14.7	7
Corn	10	23	13.8	33
	15	23	14.6	[2]
Sorghum	10	21	13.6	27
	15	21	14.1	30

[1]Moisture content of corn meal, 12.7%.
[2]Did not heat.

content of all the ingredients will have to be such that the total moisture content of the mixed feed is below the critical level.

Mixtures Containing Fat

A surplus of fat has accumulated during the past few years and a large amount of non-edible fat is being used in animal feeds. The purpose of part of these tests was to obtain information on heating when fat is added to various feed ingredients. The feed ingredients used in these tests were yellow corn meal and soybean oil meal. The fats used were mazola and lard. Mazola is corn oil refined by the Corn Products Refining Company.

Ingredient with Moisture Slightly Above the Critical Level

In one series of three separate trials, yellow corn meal with an average of 13.4 percent moisture was mixed with 0, 5, 10 and 15 percent mazola. In another trial, corn meal with 13.1 percent moisture was mixed with the same quantities of lard. The results of these tests are summarized in Table 6.

Without fat the corn meal containing 13.4 percent moisture heated in an average of 29.3 days, while the one containing 13.1 percent mois-

TABLE 5. HEATING IN MIXTURES OF ALFALFA LEAF MEAL[1] AND CANE MOLASSES

Molasses added	Moisture		Started heating
	In molasses	In mixture	
%	%	%	Days
10	20	15.2	
15	20	15.5	
20	20	15.9	
40	20	17.1	
10	28	16.2	36
15	28	16.8	23
20	28	17.6	36
40	28	20.4	

[1]Moisture content of alfalfa leaf meal, 14.3%.

TABLE 6. HEATING IN MIXTURES CONTAINING CORN MEAL AND A FAT

No. of trials	Fat: Source	Fat: Percent	Corn: Amount	Corn: Moisture content	Moisture content of mixture	Started to heat
			%	%	%	Days
3	None		100	13.4		29.3
1	None		100	12.1		[1]
3	Mazola[2]	5	95	13.4	12.3	32.0
1	Lard	5	95	13.1	12.1	39.0
3	Mazola	10	90	13.4	11.8	20.0
1	Lard	10	90	13.1	11.7	36.0
3	Mazola	15	85	13.4	11.3	21.0
1	Lard	15	85	13.1	10.6	31.0

[1]Did not heat.

[2]Mazola is corn oil obtained from the Corn Products Refining Company.

ture did not heat in 42 days. All mixtures heated when mazola or lard was added to corn meal that contained 13.4 or 13.1 percent moisture. In general, the mixtures containing fat started to heat sooner than the corn meal without fat. Also the mixtures with 10 and 15 percent fat started to heat sooner than those with 5 percent. The mixtures containing fat heated more rapidly than the corn meal without fat in spite of the fact that the mixtures contained approximately 2 percent less moisture than the corn meal that did not heat. In a second series, yellow corn meal containing 14.3, 14.0 and 14.5 percent moisture was mixed with 10 and 15 percent of mazola and with 10 and 15 percent of lard. A similar test was made with soybean oil meal that contained

TABLE 7. HEATING IN MIXTURES CONTAINING CORN MEAL OR SOYBEAN OIL MEAL AND A FAT

No. of trials	Ingredient	Moisture content of ingredient	Fat	Moisture content of ingredient + fat	Started to heat
		%		%	Days
	Feed ingredient without fat				
3	Corn	14.3	0		8
1	Corn	14.0	0		7
3	Corn	14.0	0		9
1	Corn	14.5	0		3
1	Soybean meal	13.6	0		[1]
	Feed ingredient, 90% + fat 10%				
3	Corn	14.3	Mazola	12.3	7
1	Corn	14.0	Lard	11.2	3
3	Corn	14.0	Mazola	12.1	12
1	Corn	14.5	Lard	12.3	13
1	Soybean meal	13.6	Mazola	12.1	36
1	Soybean meal	13.6	Lard	12.1	36
	Feed ingredient, 85% + fat 15%				
3	Corn	14.3	Mazola	11.9	7
1	Corn	14.0	Lard	11.1	13
3	Corn	14.0	Mazola	11.4	10
1	Corn	14.5	Lard	11.9	7
1	Soybean meal	13.6	Mazola	11.3	35
1	Soybean meal	13.6	Lard	11.2	

[1]Did not heat in 42 days.

13.6 percent moisture. The results of these tests are summarized in Table 7.

All the mixtures containing corn meal and fat started to heat about the same time as the corn meal without added fat. The mixtures of soybean oil meal and fat started to heat in approximately 35 days, while without fat the soybean oil meal did not heat in 42 days. The results with lard were essentially the same as those with mazola.

Corn Meal with Different Levels of Moisture

A third test was made to determine the effect on heating in mixtures when 10 percent mazola was added to corn meal that contained different amounts of moisture. The levels of moisture in the corn meal were 11.7, 12.9, 13.5, 14.8 and 15.0 percent. When fat was added to the various lots of corn meal, the moisture content of mixtures was 10.7, 11.7, 12.3, 13.1 and 13.5 percent, respectively. These results are summarized in Table 8.

Neither the corn meal nor the mixtures heated when the moisture content of the corn meal was below the critical level. When the moisture content of the corn meal was above the critical level, the addition of fat delayed the heating slightly.

Ingredient with High Moisture Level

A feed ingredient heats more rapidly and to a higher temperature as its moisture content increases above the critical level. Determination was made of the effect of an ingredient, with excessive moisture, on the heating cycle when it is mixed with different amounts of an unsaturated fat such as mazola. It was suspected that the initial heating produced by the growth of molds in the non-fat portion of the mixture would start oxidation of the fat, and as a result there would be an increase in the temperature in addition to that produced by mold respiration.

TABLE 8. HEATING IN CORN MEAL CONTAINING VARIOUS AMOUNTS OF MOISTURE AND IN A MIXTURE CONTAINING 90 PERCENT CORN MEAL AND 10 PERCENT MAZOLA

Corn meal alone and mixture with fat	Moisture in corn meal and mazola	Started to heat
	%	Days
Corn meal[1]	11.7	[2]
Corn meal & mazola	10.7	[2]
Corn meal	12.9	[2]
Corn meal & mazola	11.7	[2]
Corn meal	13.5	21
Corn meal & mazola	12.3	34
Corn meal	14.8	8
Corn meal & mazola	13.1	11
Corn meal	15.0	8
Corn meal & mazola	13.5	9

[1]The corn meal with and without fat contained the same amount of moisture at each level tested.

[2]Did not heat in 42 days.

Another possibility was that the mixture containing fat and high moisture ingredient might maintain a high temperature for a longer period than the same ingredient without the fat. Accordingly, one test was run to determine the rate of heating and the maximum temperature reached in mixtures containing fat and an ingredient with excessive moisture. In this test, corn meal that contained 17.5 percent moisture was mixed with 0, 10 and 20 percent of mazola. The results are shown in Figure 1.

When the corn meal contained 17.5 percent moisture, the mixtures started to heat in 1 to 2 days, regardless of the amount of fat present. The maximum temperature was reached in 9 to 11 days. The maximum temperature in the mixture containing 10 percent mazola was 117° F; in that containing 20 percent mazola, it was 124° F, while without fat it was 112° F. The temperatures of the mixtures containing 10 and 20 percent of mazola decreased to 115° and 116° F, respectively, at 14 days. The temperature of the corn meal without fat was 112° F. In this experiment, the mixtures containing fat heated to higher temperatures than those without fat. However, since only one test was run, the data are not interperted to mean that a mixed feed containing added fat will always heat to a higher temperature than one without fat. Sometimes when the moisture content was just above the critical level the ingredient heated more rapidly when fat was added, and other times it heated faster without fat. Regardless of the direction of the change, the difference in the time required for the ingredient to heat with and without fat was relatively small. Likewise, the difference in the maximum temperature reached was small;

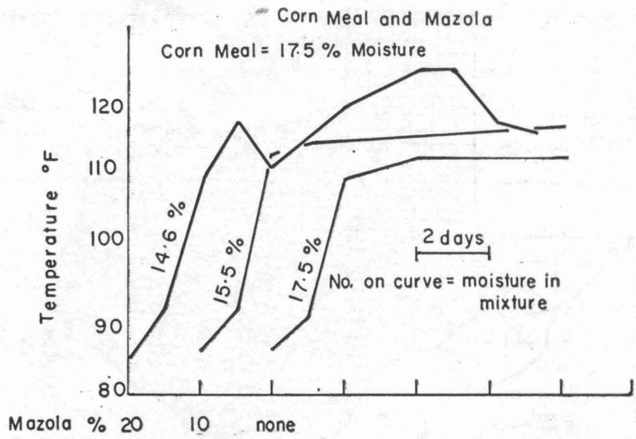
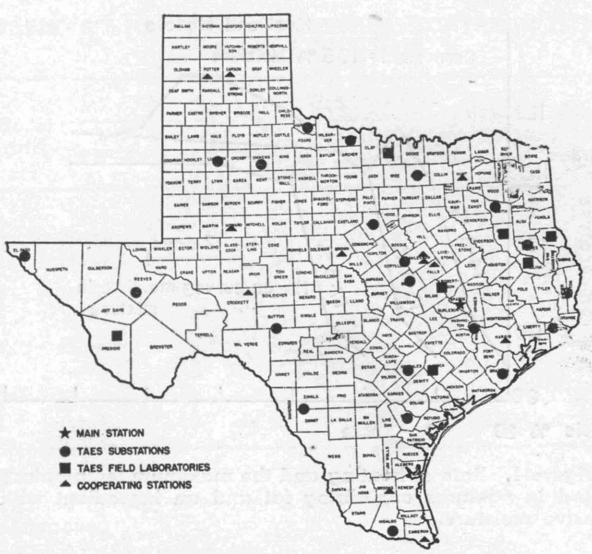


Figure 1. Rate of heating and the maximum temperature reached in mixtures containing fat and an ingredient with excessive moisture.

sometimes the temperature was higher with fat, again it was higher without fat. A mixed feed or a feed ingredient containing a large amount of fat will heat at a lower moisture level than one containing a small amount of fat. The difference is explained on the basis of the moisture content of the non-fat portion of the mixture. Assuming that two mixtures have the same moisture content, the non-fat portion of a mixture with a large amount of fat will have a higher moisture content than the non-fat portion of the mixture with a small amount of fat, because all of the moisture is in the non-fat portion of the mixture.

Table 6, 7 and 8 and Figure 1 show that the addition of fat to a feed ingredient did not cause spontaneous heating under conditions used in these tests.



Location of field research units in Texas maintained by the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

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RESEARCH RESULTS are carried to Texas farm and ranch owners and homemakers by specialists and county agents of the Texas Agricultural Extension Service.