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Factors Affecting Gummy Butter

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DIGEST

Among the Southcentral States, Texas ranks next to Oklahoma and Kentucky in creamery butter production; in farm butter production Texas is third in the nation—following Alabama and North Carolina.

Second only to flavor in the importance of eating quality is the body of butter. Body is evaluated by the consumer by the manner in which the butter melts or spreads. It is often considered that cows eating cottonseed products produce butter having what is known as a gummy or melt-resistant body.

The availability and nutritive qualities of cottonseed products make them highly desirable as dairy feeds, especially in the South.

This study shows that the gummy character of butter body may be accounted for by a no more specific reason than "individuality of the cow," regardless of her feed. On the other hand, it is shown that when grain sorghum silage is fed along with cottonseed meal, the tendency for the butter to be gummy is completely overcome. This tendency lends further weight to the already existing experimental data on the advantages of silage feeding for dairy cattle.

Feeding experiments and butter analyses show that gummy-bodied butter is higher in palmitic and stearic acids than is non-gummy butter. Gummy-bodied butter has a significantly higher melting point and Polenske number, and a significantly lower Iodine number. There is no significant difference between the Reichert-Meissl number nor the lecithin-in-fat content of gummy and non-gummy butter.

Factors Affecting Gummy Butter

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TEXAS CREAMERY BUTTER often has a gummy body. This defect can best be described by the manner in which affected butter melts in the mouth; it has a paraffin-like body that resists melting for periods much longer than does butter of normal body. Texas butter has been criticized and reduced in score at butter markets over the country because of this defect. Published research on the gummy body defect is limited. Herzer, Moore and Cowsert (1) reported that cottonseed hulls, cottonseed meal and cottonseed oil, when fed to cows, resulted in gummy butter; but if the cottonseed meal was extracted by solvents to reduce the oil content of the meal, the gumminess was not evident. The presence of silage in the ration reduced the gumminess.

Keith, Rink and Kuhlman (2), in studying the gummy defect, reported that gumminess in butter could be controlled by churning within one hour after pasteurizing and cooling. There may be some relation between this observation and that of Hansen, *et al.*, (3), that butter made from cream cooled on surface coolers is more likely to be gummy than that made from vat-cooled cream.

It was reported by Arbuckle and Copeland (4) that gumminess in butter was associated with a greater hardness value, higher melting point, higher Polenske value, lower iodine number and a lower Reichert-Meissl value. The use of pasture in the ration reduced gumminess. Gumminess was produced when either palmitic or stearic acid was fed. It was concluded that the gummy defect was associated with a high percentage of palmitin and stearin in the butter.

In a survey of the quality of Texas butter (3), it was concluded that cottonseed feeds and dry pastures were associated with gummy-bodied butter, and that these feeding conditions, as well as methods of handling cream on the farm and at the creamery, all contributed to gumminess, hardness of body and flat flavor.

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EXPERIMENTAL PROCEDURE

A study was made by the Texas Station of the effect of feeding solvent-extracted and hydraulic-processed cottonseed meal. The chemical composition of these feeds were:

Component	Solvent	Hydraulic
	%	%
Protein minimum	41	41
Fat	1	5
N-free ext. minimum	25	25
Crude fiber, maximum	13	12

Since the properties of lecithin suggest that it might be associated with a gummy-bodied butter, the amount of lecithin in butters made from the milk of cows fed the two kinds of cottonseed meal was determined. The effect of lecithin feeding was observed.

Since gumminess was produced (4) in butter when cows were fed palmitic or stearic acid, a study was made of the amounts of the several fatty acids in both gummy and non-gummy butter. Conventional fat constants were determined by the methods of the Association of Official Agricultural Chemists. The judging of body in butters was done by two or three experienced judges.

Hydraulic-processed and Solvent-extracted Cottonseed Meal

Six Jersey cows in the Station herd were selected for study. For 14 days they were given an 18 percent protein ration consisting of 565 pounds of sorghum grain, 100 pounds of citrus pulp, 100 pounds of oats, 150 pounds of bran and 250 pounds of hydraulic-processed cottonseed meal. They had free access to silage and alfalfa hay. At the end of this period, the milk from four consecutive milkings of each cow was added together and separated, pasteurized, cooled and churned into butter containing 2 percent salt. On the same day, for comparison, a churning was made of cream from mixed patron milk. The butters were stored at 40° F. and examined for gumminess after one week. The Reichert-Meissl number, Polenske number, iodine number, melting point and lecithin-in-fat percentage were determined. Cottonseed meal and silage in the ration were replaced with Johnson grass hay and corn gluten meal. A 22 percent protein mix, consisting of 200 pounds of sorghum grain, 200 pounds of oats, 100 pounds of bran and 250 pounds of corn gluten meal, was fed for 28 days. Milk samples were again collected, separated, pasteurized, and churnings were made.

The six cows were then grouped into three pairs. For 14 days their rations were the same as those fed during the cottonseed-depletion period, except that: pair one received solvent-extracted cottonseed meal; pair two received hydraulic-processed cottonseed meal, and each cow of pair three was fed 25 grams of crude commercial soybean lecithin on alternate days via a balling gun. Pair three received the same grain ration as pairs one and two, except that it received no cottonseed meal. Then pairs one and two were reversed for 14 days, and the lecithin feeding to pair three was discontinued. Pair three was fed the basal ration (containing hydraulic-processed meal) during this period. Churnings again were made; fat constants were determined and examinations for gumminess were made. The results are shown in Table 1.

Table 1. Fat constants, lecithin content and the incidence of gumminess in butters from six cows fed hydraulic and solvent-processed cottonseed meal in a single reversal test

Physical and chemical characteristics of butter	Cow number: 1	2	3	4	5	6	Mixed-patron milk
	After 14 days basal diet containing hydraulic cottonseed meal						
Reichert-Meissl	24.48	28.99	26.80	26.15	26.12	29.20	27.98
Polenske	3.11	2.24	3.18	3.58	2.52	3.12	2.07
Iodine	28.54	30.33	28.45	28.04	28.64	31.19	30.92
Melting point	33.9	33.0	33.4	33.2	33.0	32.8	35.2
Lecithin-in-fat, ether ext.	.164	.148	.156	.142	.166	.160	.173
Body of butter	Gummy	Good	Good	Good	Gummy	Good	Gummy
	After 28 days depletion period—no cottonseed meal fed						
Reichert-Meissl	22.06	26.26	23.78	24.02	22.64	26.38	
Polenske	2.24	3.18	2.42	2.82	2.05	2.56	
Iodine	33.50	32.52	36.53	31.98	35.36	36.02	
Melting point	33.8	31.8	32.6	33.2	34.1	33.0	
Lecithin-in-fat, ether ext.	.176	.278	.191	.285	.223	.245	
Body of butter	Good	Good	Good	Good	Good	Good	
	After 14 days on diet that included						
	Lecithin		Solvent-extracted cottonseed meal		Hydraulic-processed cottonseed meal		
Reichert-Meissl	20.38	24.49	25.63	23.47	23.69	26.39	
Polenske	1.62	2.97	1.99	2.98	2.65	1.92	
Iodine	31.18	30.68	30.83	29.80	30.68	33.19	
Melting point	35.6	33.0	33.6	34.2	32.6	34.2	
Lecithin-in-fat, ether ext.	.147	.093	.178	.128	.134	.160	
Body of butter	Good	Good	Good	Gummy	Gummy	Good	
	Reversal: After 14 days on diet that included:						
	Basal diet		Hydraulic-processed cottonseed meal		Solvent-extracted cottonseed meal		
Reichert-Meissl	23.45	25.74	24.43	25.30	23.25	27.64	26.21
Polenske	2.18	2.43	2.11	2.50	2.22	2.15	1.65
Iodine	35.33	30.66	34.45	32.46	32.68	33.52	34.18
Melting point	32.8	33.1	35.0	35.0	35.4	35.1	35.5
Lecithin-in-fat, ether ext.	.235	.198	.199	.190	.193	.217	.207
Body of butter	Good	Good	Gummy	Gummy	Gummy	Good	Good

Table 2. Incidence of gummy butter from cows fed hydraulic and solvent-extracted cottonseed meal and corn gluten meal

Feed	Cow number																										
	7			8			9			10			11			12			13			14			15		
	After feeding, weeks									After feeding, weeks									After feeding, weeks								
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Grain without corn gluten meal Plus solvent-extracted cottonseed meal	+[1]	+	+	+	+	+	+	+	+																		
Grain without corn gluten meal Plus hydraulic-processed cottonseed meal	+	+	+	+	+	+	+	+	+																		
Grain without corn gluten meal Plus hydraulic-processed cottonseed meal										+	−[2]	−	+	+	+	−	−	−									
Grain without corn gluten meal Plus solvent-extracted cottonseed meal										−	+	−	−	+	−	−	−	−									
Grain with corn gluten meal No cottonseed meal. Same																			−	−	−	−	−	−	+	−	−
Continued for 6 weeks No reversal																			−	−	−	−	−	+	−	−	−

[1] + gummy
[2] — not gummy

A similar feed reversal experiment followed, using three new groups with three cows in each group. None of these cows was used in the first study. For convenience, they are referred to as numbers 7 to 15 inclusive. The experimental groups were fed 5 pounds daily of solvent-extracted or hydraulic-processed meal. The ration fed with either type of cottonseed meal consisted of 200 pounds of sorghum grain, 200 pounds of oats and 100 pounds of bran. The control ration was the same except that it contained 250 pounds of corn gluten meal to replace the cottonseed meal. Four consecutive milkings again were collected from each cow at weekly intervals for 3 weeks. The milk was separated, pasteurized, cooled to 50° F., and churned after 12 hours of aging. The butters were stored at 40° F. and examined for gumminess after one week. Fat constants were determined as in the previous experiment. The incidence of gumminess is shown in Table 2.

In a third feeding trial, grain sorghum silage was added to the rations. The grain mixes and the two types of cottonseed meal were fed as in previous trials in a single reversal test. Butter samples were prepared in the same manner and examined for gumminess. Two weeks after the addition of the sorghum silage, there were no gummy butters from the 6 cows studied (numbered 16 to 21, inclusive) regardless of whether they were fed hydraulic or solvent meal. After 3 weeks, butters were again churned. None of the 6 samples was gummy. The results are shown in Table 3.

Fatty Acid Composition of Butter

About 240 grams of butterfat were refluxed for 24 hours with 2 liters of absolute methyl alcohol containing 5 percent sulphuric acid, to convert the glycerides to methyl esters. Most of the alcohol was then boiled off. This alcohol, containing the butyrate and caproate, was not reclaimed. The remaining esters were exhaustively extracted with ethyl ether and were washed three times with 100 ml. quantities of water. The ether solution was desiccated over sodium sulphate, filtered, and the solvent almost completely removed over a steam bath at ordinary pressure. The remaining solvent was removed at reduced pressure.

Two hundred grams of the esters were placed in a flask and connected to an electrically heated and packed fractionating column, after the method of Smith and Dastur (5). The composition of each fraction was determined according to the methods of Hilditch (6). Polyunsaturated esters were

Table 3. The production of non-gummy butter when sorghum silage was fed with either hydraulic or solvent-extracted cottonseed meal

Feed	Body of butter from cow number					
	16	17	18	19	20	21
Pasture plus basal grain mix—no cottonseed meal	—[1]	—	—	—	—	—
	After 14 days					
Grain mix only—no cottonseed meal	—	—	—	—	—	—
	After 21 days basal grain mix plus					
	5 lbs. hydraulic-processed cottonseed meal daily			5 lbs. solvent-extracted cottonseed meal daily		
Sorghum silage	—	—	—	—	—	—
	After 21 days basal grain mix plus					
	5 lbs. solvent-extracted cottonseed meal daily			5 lbs. hydraulic-processed cottonseed meal daily		
	—	—	—	—	—	—

[1] — not gummy.

then determined by the ultraviolet spectrophotometric alkali isomerization technique of Beadle and Kraybill (7). Percentage distribution of the total fractions of the methyl esters of saturated and unsaturated fatty acids for two samples of normal and two of gummy-bodied butter are shown in Table 4.

DISCUSSION

Table 1 shows that none of the six cows studied produced fat having a gummy character in butter, after their rations were depleted of cottonseed meal for 28 days. Butter made of the milk of two of the cows showed gumminess before the depletion period began and during the time each was receiving hydraulic-processed meal in a basal ration. The effect of hydraulic-processed meal is not consistent, however, because in the reversal feeding trial the two cows which were returned to the basal diet following lecithin feeding, produced butter that was not gummy. The effect of solvent-extracted meal was also inconsistent. While these data show, in general, that hydraulic-processed meal has more of a tendency to produce gumminess than does solvent-extracted meal, the tendency is not uniform. It is apparent that the individuality of the cow, regardless of her feed, is a factor controlling the character of her fat. The six cows in this phase of the study had been fresh from 1 to 7 months when the study began.

No relation between their stages of lactation and the incidence of gumminess in their churned fat was observed.

Results of another reversal feeding test, shown in Table 2, substantiate those in Table 1. While there is convincing evidence of the tendency for either type of cottonseed meal to produce gumminess in the case of cows 7, 8 and 9, there is again the inconsistency of this tendency in the case of cows 10, 11 and 12. Corn gluten meal as a source of protein in the ration is better from a butter body standpoint than is either type of cottonseed meal. All of the fat constants reported in Table 1 were determined in the study reported in Table 2. Statistical treatment of the fat constant data on 41 samples of gummy and 45 samples of non-gummy butter indicates that, in gummy butter, the Polenske number and melting point is significantly higher, that the iodine number is significantly lower, and that there is no difference in Reichert-Meissl number nor in lecithin-in-fat content.

Complete absence of gumminess in butter occurred when grain sorghum silage was fed along with either type of cottonseed meal. As shown in Table 3, when 5 pounds of either type meal were fed for 21 days, there were no samples of gummy butter. It is significant here that the indefinite effect associated with the "individuality of the cow" was completely overcome, so far as gummy butter is concerned, when the cows were fed grain sorghum silage.

An analysis of the fatty acid composition of gummy and non-gummy butters suggests (Table 4) that gumminess is associated with higher percentages of long-chain acids,

Table 4. Percentage distribution of the total fractions of methyl esters in normal-bodied and gummy-bodied butter

Fatty acid fraction	Trial 1		Trial 2	
	Normal	Gummy	Normal	Gummy
Saturated				
C8	1.07	0.73	1.38	0.78
C10	3.39	1.90	3.48	2.98
C12	5.15	3.32	1.59	2.85
C14	13.63	11.77	15.48	8.93
C16	25.22	26.21	34.27	39.90
C18	9.87	13.82	10.86	8.98
C20	1.35	2.55	1.52	0.90
Unsaturated				
C10	0.28	0.10	0.40	0.15
C12	0.28	0.12	0.10	0.12
C14	1.04	1.04	1.85	1.40
C16	2.30	2.25	2.37	3.73
C18 oleic	35.06	34.97	24.66	24.45
C18 linoleci	0.34	0.54	1.28	3.58
C18 linolenic	0.87	0.34	0.52	0.86
C20	0.06	0.38	0.23	0.37

particularly palmitic. Non-gummy butter is characterized by higher percentages of short-chain fatty acids. This confirms, in part, the study made by Arbuckle and Copeland (4) who observed that cows fed palmitic and stearic acids produced gummy butter.

SUMMARY AND CONCLUSIONS

Hydraulic-processed or solvent-extracted cottonseed meal in a dairy ration tends to produce fat which, when churned into butter, has a gummy body.

Hydraulic-processed cottonseed meal has more effect in producing gumminess than does solvent-extracted meal.

Neither type of meal is consistent in its effect.

The individuality of the cow determines to a great extent whether her fat will produce gummy butter.

When sorghum silage is fed along with either hydraulic-processed or solvent-extracted meal, the fat produced does not result in a gummy butter, regardless of the individuality of the cow.

The lecithin content of ether-extracted fat is not an index to the incidence of gumminess in the churned fat. There is no relation between the Reichert-Meissl number of fat and the incidence of gumminess in butter.

Gummy butter has a higher Polenske number and a higher melting point, but a lower iodine number, than non-gummy butter.

There appears to be more palmitic acid in gummy butter.

There are higher percentages of short-chain fatty acids in non-gummy butter.

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LITERATURE CITED

(1) Herzer, F. H., Moore, J. S., and Cowsert, W. C. The Effects of Various Feeds on the Milk Fat Constants and on the Flavor and Texture of Butter. Miss. Agr. Expt. Sta. Tech. Bull. 25. 1939.

(2) Keith, J. I., Rink, C. W. and Kuhlman, A. H. Overcoming the Gummy Body of Butter Caused by Feeding Cottonseed Meal. J. Dairy Sci., 20:462. 1937.

(3) Hansen, F. E., Arbuckle, W. S., and Shepardson, C. N. Factors Affecting the Quality of Texas Butter as Revealed by a Statewide Survey. Tex. Agr. Expt. Sta. Bull. 670. 1945.

(4) Arbuckle, W. S., and Copeland, O. C. Factors Affecting the Quality of Texas Butter. Tex. Agr. Expt. Sta. Progress Rpt. 1031.

(5) Smith, J. A. B., and Dastur, N. N. The Effect of Inanition on the Yield and Composition of Milk Fat. Biochem. Jour. 32:2:1868-1876. July-Dec. 1938.

(6) Hilditch, T. P. The Chemical Consitution of Natural Fats. 2nd Ed. 1947. London, Chapman and Hall.

(7) Beadle, B. W., and Kraybill, H. R. The Spectrophometric Analysis of Fats. J. Amer. Chem. Soc. 66:2:1232. July-Dec. 1944.